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Inside

From the Director's Desk

History of IGCAR Library – Networking Minds and People

"Library is the Heart and Soul of a Strong Organization" goes the popular adage. It is not an exaggeration to say that these words are perfectly true for our Centre, which has a treasure house of information and knowledge resources, tirelessly and painstakingly collected over the years.

The Library at our Centre has grown into its present stature of "Scientific and Information Resources Division" from being "Library and Documentation Services" and later on "Library and Information Services". In line with the metamorphosis, the services offered have also multiplexed in quality and quantity over the past three and a half decades. What started in the conventional way assumed the mantle of information service, which moved on to computer based automated services and today it has matured into a digital world and a knowledge resource hub with relevant information available at the click of the mouse.

The Library at the Centre was born in 1972, when the Centre was very young. It started with three thousand books and subscription to a dozen of journal titles. The Centre grew at a fast pace with activities encompassing basic physics to environmental science not leaving out the mission oriented research on fast reactor technology. The management of library was posed with a challenge to keep pace with this rapid growth and cater to the requirements of a diverse science, engineering, technology and administrative communities. The fact that the township and Centre were away from the metropolitan city posed additional challenges. We have come a long way since then, and today the library possesses over sixty five thousand books, more than two lakh reports in the form of microfiche and hard copies, twenty thousand standards, forty thousand bound periodicals and eight hundred current journals with digital library services. It is indeed a commendable achievement. A good library not only means good service to the users, but it is also unique since its vast collection offers something to pick up from for everyone despite their diverse backgrounds and requirements. Besides a systematic, ordered and efficient display of books and journals, the meticulous attention paid over the years to the launch and development of various information services has paid rich dividends in shaping it into a world-class library. I would like to recall some of the history and highlight the achievements of the library at our Centre.

> ***The Library connects us with the insight and knowledge, painfully extracted from Nature, of the greatest minds that ever were, with the best teachers, drawn from the entire planet and from all our history, to instruct us without tiring, and to inspire us to make our own contribution to the collective knowledge of the human species. I think the health of our civilization, the depth of our awareness about the underpinnings of our culture and our concern for the future can all be tested by how well we support our libraries.*** *- Carl Sagan, Cosmos*

The Beginning

The story of the robust growth of library at our Centre to its present stature of Scientific Information Resource Division is interesting. Though the Centre was established in 1968/69 the library came into existence only in 1972 with the arrival of additional holdings available at Bhabha Atomic Research Centre (BARC) Library. These constituted books in physics, metallurgy and nuclear engineering and served as the core collection of the Centre.

The activities of library began in a small room at the zonal workshop building, later shifted to a bigger area at Central Design Office building in January 1973 and functioned under the guidance of Shri A. Venkateswarlu, Engineer-in-Charge, zonal workshop. The main objective then was to collect and supply documents and information relevant to the scientists and engineers engaged in research in various fields of Fast Breeder Reactor Technology. The three thousand odd books were kept in closed access with a departmental staff. A library subcommittee was constituted to look into the affairs of the library, while the committee functioning at BARC was reposed with the responsibility of shaping the library with the necessary infrastructure and equipment.

Library: Here is where people, one frequently finds, lower their voices and raise their minds. -Richard Armour

To meet this goal, the Library Committee at BARC deputed a few of its committee members including Dr. Kanwar Krishan and Shri M.K. Kelkar of Library & Information Services (L&IS), BARC, to visit the library at our Centre for a fortnight to review the procedures, suggest improvements and changes to the environment. The Library was rechristened as "Library and Documentation Services" with the commencement of the reprographic and re-packaging services for the documents. In this period, the work programme of library was guided by two separate committees namely "Library Committee" and "Documentation Committee". The "Library Committee" was chaired by Shri A. Venkateswarlu; Shri R. Shankar Singh was one of the members. The committee initiated steps to appoint a colleague with library science background for overseeing the future of library. Shri L.V. Krishnan was the chairman of the "Documentation Committee". The two committees had sufficient interplay with some of the members being common to both. The procurement of books was constantly enhanced to match the increasing needs and the complexities of the requirements of the users in the Centre. The technical processing activities like classification and cataloguing gained momentum with the appointment of an officer to oversee the operations in 1973. The period, 1973-1979, was marked with rapid expansion of library and documentation service activities at the Centre.

All Round Growth

During the end of 1973, Dr. G. Venkataraman, fondly referred as Dr. GV, who took over as Head, Materials Science Laboratory, IGCAR chaired the "Library Committee" and took keen interest in its affairs.

Dr. G. Venkataraman, the father of the present Library

He initiated steps to transfer Smt. N. Nagarathna, from BARC-Library as a full time Officer In-Charge of the library. She initiated steps to procure a number of documents by placing standing orders for National Technical Information Services (NTIS) Reports of selected research in microfiche (SRIM) category in more than forty-three subject classes encompassing frontier areas in nuclear science and technology. Shri D. John Vincent, with twelve years of experience at the Institute of Mathematical Sciences, Chennai, also joined the library at this time. Both of them drafted procedures for building of the library with respect to procurement of books, journals, standards, reports and back-volumes in microfilm etc. They also initiated steps to increase the number of staff to cater to the increasing demands. Many new services like photocopying, printing and publishing RRC Report (now IGC Report) and binding tender documents were introduced during this period.

If you have a garden and a Library, you have everything you need. - Cicero

The first IGC report was published in 1973 comprising of the papers presented at the seminar on "Radiation Damage in Reactor Materials" held at BARC in 1972. Subsequently, the library committee at RRC formulated guidelines for publication and compiled a style manual. Members were issued borrower tickets and activities like circulation, accession of new books and other documents and processing of bills for making payments commenced, on a regular basis. As a prelude to computerization of library holdings, providing keywords for books using the Thesaurus of "International Nuclear Information System (INIS)" and "Thesaurus of Engineering and Scientific Terms (TEST)" to maintain uniform vocabulary control was initiated in 1977. The make-shift library occupying a single room in the Design Hall II expanded to occupy an independent building of ten thousand square feet in 1979.

Computerization of the library was initiated as early as 1980 by the missionary zeal of Shri D. John Vincent. During 1980, book data cards for each document containing the bibliographic details were entered using "Hollerith Card Punching" machine installed in the Computer Division, which were then sent to Computer Centre at IIT Madras for further processing. The processed data, created in a unique way by assigning a maximum of sixteen keywords to describe each book, were then

Old Library building reminds Dr. S. R. Ranganathan's fifth law of Library Science "Library is a Growing Organism"

converted into magnetic tape media for content level access.

Dr. GV's encouragement and support for automation, improving book collection and indexing of key words in an electronic format helped the library to scale greater heights. The success in testing of the retrieval software, written in Fortran-IV, with the help of Dr. R.Krishnaswamy of Materials Science Laboratory and tested at the IBM370/155 computer at IIT Madras encouraged us to proceed towards total automation of various library activities. A software "TEXTPACK", written in lower assembler language and available with IIT Madras was used to perform various functions like book and document search, maintenance and out put preparation as required by the users.

Libraries are reservoirs of strength, grace and wit, reminders of order, calm and continuity, lakes of mental energy, neither warm nor cold, light nor dark.... In any Library in the world, I am at home, unselfconscious, still and absorbed.

-Germaine Greer

Consolidation

Under the leadership of Shri R. Shankar Singh as Chairman of Library Committee, during the period 1979 - 1988, the library made considerable progress by way of introducing modern management methods and changes in organizational structure. Book Information Retrieval Database System (BIRDS), the first online catalogue available over the Time Sharing System (TSS)

(Late) Dr. Kanwar Krishan, who served as Co-Chairman, Library & Information Services Committee and Shri. D. John Vincent were firm with their commitment to enhance the library services

using the DM-IV database management system was commissioned and was available online in terminals located at different laboratories in the Centre. Computerized catalogue card printing was an extension of BIRDS database and new services like Content/Index (CONINDEX) and Title list (TITLIST) were initiated during this period.

Copies of content/index pages of important journals/ annual serials in nuclear engineering, materials science and metallurgy, chemical engineering, electronics and instrumentation etc. were prepared and circulated for the benefit of the users.

The Library geared up to the growing needs of the Centre by improving upon subscription to core journals and back volumes with addition of books. The phenomenal growth of subscription to four hundred and fifty journals was achievable only with the proactive steps taken by the management. In order to minimize the space requirement and to preserve the documents for a longer time, it was decided to procure them as microfilms. The microfilm and microfiche readers were developed in-house by the central workshop of our centre for use in the library.

A well equipped bindery and reprography units were set up for binding the back volumes of journals and repairing of worn-out or damaged books. The binding services were extended to cater to the general needs of scientific and tender documents related works. Photocopying work carried out at Materials Science Laboratory was shifted to

Shri R. Shankar Singh, Dr. G. Venkataraman and Shri D. John Vincent looking at the circulation system using Barcode Technology

the library premises to facilitate the user to make copies from microfilm/microfiche. Photocopying of documents started with manual plate insertion type at Central Design Office building with arc lamps and camera followed by the liquid type toner machine, which was subsequently replaced with powder toner photocopying machines. Later a treadle printing press was also installed for printing cover page and wrappers for various conference proceedings.

The in-house photography unit was established to record the progress at the construction site of FBTR and document other important activities of the Centre. Black & White film processing and printing facility was installed due to the efforts of Shri N.L.Char, former Principal Project Engineer (Design). This facility has further helped to document all the historic occasions/ important events in the Centre, which were integrated to form the photographic image archive. In addition, preparation of

Sarabhai Auditorium had an opportunity to have pioneers and eminent personalities

the overhead projection slides for various lectures and filming work related to printed circuit board manufacturing facility at Electronics & Instrumentation Division were undertaken by the photography unit.

A French Cell, then headed by Shri N.L. Char was created for the coordination and liaison with the French engineers, engaged in the construction activity of FBTR. The cell was providing translation services of important documents, which were subsequently integrated with the library in 1982, German to English translations, were also undertaken.

A modern and well-equipped auditorium with a seating capacity of over three hundred (named subsequently as *Sarabhai Auditorium*) was constructed during the eighties at the General Services (presently *Homi Bhabha)* Building. The auditorium was well equipped with the state-of-the art facilities for audio-visual and projection systems. The auditorium and new building for Library was inaugurated by Shri R. Venkataraman, former President of India, and became functional in June 1988.

Scientific Information Resource Division (SIRD) provides services to three auditoriums viz., Sarabhai and Ramanna Auditoriums at our Centre and the Convention Centre at Anupuram.

Computerization and Automation

The 1990s witnessed revolutionary changes in the history of our library. The vision and meticulous approach of Dr. C.K. Mathews, the then Director, Chemical Group, who took over as the Chairman of Library & Information Services Committee, provided the necessary impetus to introduce modern information techniques/services like CD-ROM, Online Access, DTP, e-mail etc., for the benefit of the users. The e-mail facility, which commenced in 1991, as a USER NODE through Scientific and Industrial Research Network (SIRNET) of Indian National Documentation Centre (INSDOC) Regional Centre, Chennai was upgraded into a multi-user facility as MAILNODE using the Education and Research Network (ERNET) facility at IIT-Madras for transmitting/receiving messages. The e-mail facility was later extended to various laboratories using Time Sharing System (TSS) terminal network available at the Computer Division.

The CD-ROM facility was introduced during 1990-91 and few abstracting and indexing journals were subscribed including INIS ATOMINDEX. In 1992, the data on tape was migrated from DM-IV database and uploaded to PC-based Relational Database Management System on INGRES. A user interface in 3GL was developed and the circulation activities were automated in a client-server model on Ethernet network using baseband coaxial cable with Bayonet Nut Coupling (BNC) connectors. Training courses were conducted regularly for the benefit of users to have direct access to this facility. During this period, the much-famed Barcode system was introduced, for easy, quick and accurate computer based data processing.

Barcoding involved labeling of over 65,000 books and membership cards of 5000 employees. The circulation subsystem was automated and various operations such as issues, returns, renewals, reservations, membership record keeping, generating due-slips, fine recovery slips, reservation intimation slips and user statistics could be performed with ease.

IGCAR library actively participated in the formation of

The patrons often consulted high impact journals and the reference collections

Madras Library Network (MALIBNET). As one of the major resource center in the network, our library prepared a large amount of data from over two hundred journals. Table of Contents of these journals captured in a floppy diskette were sent to the MALIBNET nodal computer at Chennai, for further dissemination to other libraries. A close liaison between our Centre and institutions like Institute of Mathematical Sciences, Indian Institute of Technology and Anna University was established during this time to share the available information for effective utilization of resources.

The library upgraded its reprographic facilities by addition of RISOGRAPH, a high speed copying machine specially purchased for the preparation of IGC reports, and the Minolta RP 505 Reader Printer in 1984.

The publication of the annual IGC Highlights to document important achievements and breakthroughs of each year was initiated. With the increased demand to pursue high quality publishing jobs, procurement of publishing software called "*VENTURA*" and "Wordstar" integrated with personal computer, laser printer and scanner (Black & White) saw the beginning of "Desk Top Publishing (DTP)" activities in this Centre, which until then was carried out in private publishing houses at Chennai. At the end of April 1997, Dr. S. Venkadesan, a metallurgist, with initiative and interest in the activities of the library was designated as Head, Library under the Library & Information Serives Committee chairmanship of Dr. S. M. Lee, then Director, SHINE Group. This team took modernization and enhancement of library, with passion and imagination, in collaboration with the Supercomputing Educational Research Centre (SERC) at the Indian Institute of Science, Bangaluru. A digital library infrastructure with server class computers, portable document scanners and mirror servers were installed with the expertise from SERC, particularly Prof. N. Balakrishnan, then Chairman, SERC. An effort was made to amalgamate all the DAE libraries under one umbrella and form DAE consortia to formulate single software, "LibSys" for the library management services. During the end of 1999, library & Information Services, subscribed to Elsevier's "Science Direct" under the aegis of this consortia. In May 2000, the first digital scanner printer was commissioned for digitizing Microfilm documents.

Information services like "Online Public Access Catalogue (OPAC)", bibliographic database, electronic content and full text archive were made available online through the "VAIGAI" server. The other forms of information retrieval using CD-ROMs and computer storage (directly or through the Internet) were also implemented. Our Library has always been striving to provide access to networked information. In this endeavor, the "Library LAN" with more than forty fast Ethernet nodes connected through an "Asynchronous Transfer Mode (ATM)" switch to the "Campus Backbone Network" for access from the desktops of scientists and engineers located at different locations of the Centre was accomplished. The Metadata pertaining to library resources like books, reports, standards and serials are being stored in 'Library Transaction Server' for providing online access to users.

A decision was taken in 1995 to form the Kalpakkam Chapter (KC) of Madras Library Association (MALA) in order to disseminate the expertise and know-how gained in the field of library and automation development. It was also decided to organize the biennial national conference on Recent Advances in Information and Technology (READIT) which is being conducted successfully till date.

The bi-annual Conferences on READIT- were held at our Centre with the major themes as "Digital Library" and "Knowledge Management", where both invited and contributory research papers were presented. Each conference has attracted more than one hundred and fifty library and information professionals from all over the country. Along with the conference, it is a practice to organize a one day pre-conference tutorial for the benefit of practicing librarians and IT professionals. This series of conferences have brought awareness among library professionals on the state of the art technology, its standards, objectives, initiatives and implementations of "Digital Libraries" and building institutional repositories.

The CD-ROM bibliographic databases like INIS, NTIS, METADEX, INSPEC-Physics, Compendex and Chemical Abstracts, Current Contents and Material Science Citation Index etc., were made available on our Intranet. The Juke-

Online and CD-ROM access facility and the servers at the Library

Dr. Placid Rodriguez delivering his presidential address during READIT-95 Conference with Dr. Kanwar Krishan, Dr. G. Venkataraman, Dr. S. Ramani, Director, National Centre for Software Technology, Mumbai, Dr. C.K. Mathews and Prof. R.S. Ganapathy, Academy of Management Excellence, Chennai were on the dais

box having 480 CD-ROM capacity was used for information retrieval from CD-ROMs received along with print issues to books, journals, encyclopedias and proceedings. The CD Mirror server also contains digitized full text standards from BIS, ASTM and ISO. The multimedia workstation consisting of scanner, authoring tools, audio-video embedding facilities were made available for preparing presentations/tutorials and capsules for lectures and seminars. Journals were also subscribed in the electronic form and are available at our linux based server for providing the "Science Direct On Site (SDOS)" service for accessing full text and articles in journals from the user's desktops.

During this period, Library & Information Services placed much emphasis on digital archiving principles to preserve knowledge resources for future generations. All the scientific and technical publications and in-house publications from IGCAR were digitized for preservation and made available over the intranet. The Library was also renamed as the Scientific Information Resource Division (SIRD). Dr. S.Venkadesan was succeeded by Shri M. Somasekharan in April 2003. He headed the SIRD, under the successive Group Directors Shri S.Govindarajan and Shri M.Rajan in Safety Group. During this period Shri P. Swaminathan, Director, Electronics & Instrumentation Group has taken over as Chairman, Library & Information Services Committee.

Prof. S.P. Thyagarajan, the then Vice-Chancellor of University of Madras, Dr.T.Ramasami, the then Director, Central Leather Research Institute, Chennai with Dr.Baldev Raj, Director, IGCAR during inauguration of the exhibition as a part of READIT-2005

READIT Meetings

READIT-95 (23rd March 1995):	**Recent Advances in Information Technology**
READIT-97 (23rd April 1997):	**Recent Advances in Information Technology**
READIT-99 (28-29, October 1999):	
Conference Theme	: **Digital Libraries**
Pre-conference tutorial	: **Library Automation & Digital Library**
READIT-2001 (18-19, September 2001):	
Conference Theme	: **Digital Asset Management**
Pre-conference tutorial	: **Digitize your Library**
READIT-2005 (14-15, July 2005):	
Conference Theme	: **Digital Libraries to Knowledge Systems**
Pre-conference tutorial	: **Advanced Methods and Technologies for Content Management & Application of Open Source Solutions for Digital Libraries**
READIT-2007 (12-13, July 2007):	
Conference Theme	: **Information to Knowledge: Technology & Professionals**
Pre-conference tutorial	: **Web Tools and IT Enabled Services**

Shri M. Somasekharan, with over thirty years experience in the installation and maintenance of computer systems/ networks steered the creation of digital content, dissemination and long time preservation. Under his guidance the rack mountable high end servers, Network-Attached Storage (NAS), Tape library, Gigabit switches and various scanners were commissioned. The Library services, its role and contribution to the content creation and collection development has been completely moved to digital environment and has finally converged to a Knowledge Resource Center.

The Library users and collection have grown manifold over the years, which are not without its share of challenges, such as: capturing multiple books and member data at same time, Tracking a misplaced document, stock verification and pilferage of the document. Radio

Smooth transition of the circulation system from Barcode technology to RFID system

Bibliographic/full text of digital resources available at IGCAR Library
Intranet Access
International Nuclear Information System (INIS)
Nuclear Science Abstracts
Materials Science Citation Index
Chemical Abstracts
Science Direct on Site: E-Journals
ASTM Standards - Full Text
British Standards – Selective update
Indian Standards - Full Text
FBR – Conference Proceedings - Full Text
Institute of Electro Technical Commission – Selective update
Powder Diffraction File
Kirk-Othmer Encyclopaedia of Chemical Technology
Online Access
METADEX
Engineering Village: Compendex, Inspec, NTIS
Science Direct : E-Journals
Science Direct Back file : Materials Science, Physics & Mathematics
Institute of Physics (IoP) - Full Text

Frequency Identification (RFID) based Circulation System has been installed. The most significant advantages are that many RFID-tagged books can automatically and simultaneously be read, contrary to bar codes, which must be scanned sequentially. An antitheft function is built into the RFID-tag, specifically for library applications to protect the documents. With the implementation of RFID, multiple books can be issued and returned at the transaction counter, making the process time effective.

The beginning of 2008 saw Dr. M. Sai Baba taking over as Head of SIRD. With his keen interest in academic pursuits and research, is a guide and friend to researchers of Homi Bhabha National Institute(HBNI) and Training School Officers. He is molding the library services to cater to the needs of students and researchers as much as for the scientific professionals.

This has also coincided with the Centre playing an enhanced role as an academic institution, with the starting of Training School and HBNI programs. More than one hundred research scholars are presently in place pursuing their doctoral programs at the Centre. The SIRD is now gearing up to cater to the needs of student community. With SIRD becoming part of Electronics and Instrumentation Group, Shri P. Swaminathan, Director, EIG is providing guidance with emphasis on digital content enhancement.

SIRD is also serving as information resource centre for the employees of all the DAE units at Kalpakkam. With increased R&D activities of BARC Facilities and BHAVINI, the number of users have almost doubled in the recent times and SIRD is efficiently catering to the increased demand.

Today, SIRD has attained the status of a full-fledged "Electronic Library" where it possesses capabilities for information access from various resources. A significant number of users have already begun to use and benefit from the various knowledge resources. I have taken the initiative to create a unique Knowledge Management policy and its implementation.

KNOWLEDGE MANAGEMENT POLICY OF OUR CENTRE

"Indira Gandhi Centre for Atomic Research(IGCAR) will consistently endeavor through concerted efforts of all it's employees to generate, archive, manage and disseminate the valuable knowledge for improving it's productivity and achieve & sustain world class leadership in all it's Scientific and technological research and Development activities."

The Library is steadily moving towards becoming a "Knowledge Resource Centre". The trained and experienced staff of Scientific Information Resource Division has now to re-dedicate themselves to accomplishing this mission.

I wish them all success in their endeavour and await many more laurels.

A good Library is a place, a palace where the lofty spirits of all nations and generations meet.
- Samuel NIGER

(Baldev Raj)
Director, IGCAR

Development on New Design of Secondary Cold Trap for Fast Breeder Reactor

Cold traps are employed in sodium system of Fast Breeder Reactor's for maintaining the oxygen/hydrogen levels in sodium within acceptable limits. It works on the principle of crystallization and precipitation of oxides/hydrides of sodium in a wire mesh when the temperature is reduced below the saturation temperature.

The cold trap in the secondary circuit, hydrogen impurities arise due to the diffusion of hydrogen through the wall of the tube into sodium in the steam generator. In the present design of secondary cold trap (Figure 1), the shell of the cold trap is cooled throughout its height and the minimum temperature is at the bottom. Hence, there is a tendency for the impurities to precipitate close to the bottom, resulting in premature plugging of the cold trap. Cold trap in the present design has a capacity of 20% of total wire mesh volume. With a view to improve the trapping capacity, a new design of cold trap has been carried out.

The new design (Figure 2) consists of a cooling zone at the top (for allowing deposition of sodium hydride) and an isothermal zone at the bottom (for deposition of sodium oxide). The new design is based on the fact that sodium hydride deposition occurs better with a temperature gradient of about ten degrees, whereas oxide impurities need greater residence time for precipitation. The cooling zone is restricted to the top half of the cold trap, thus allowing increased residence time for the impurities to crystallize in the isothermal zone in the bottom half. In isothermal zone, if a single concentric wire mesh is provided, again there is a possibility of choking due to deposition in the outer region. With this in view, four concentric graded wire meshes, with gaps in between to allow free sodium flow was considered in the new design. This increases the sodium entrance area to the wire mesh by nearly three times of the present design for crystallization of impurities. In the cooling zone (upper half), trays with wire mesh having sufficient gaps for sodium flow have been provided.

In order to evaluate the new design, a model cold trap (Figure 3) has been fabricated and tested. An accelerated test of the model cold trap was conducted by injection of pure hydrogen gas into the sodium and the quantity of

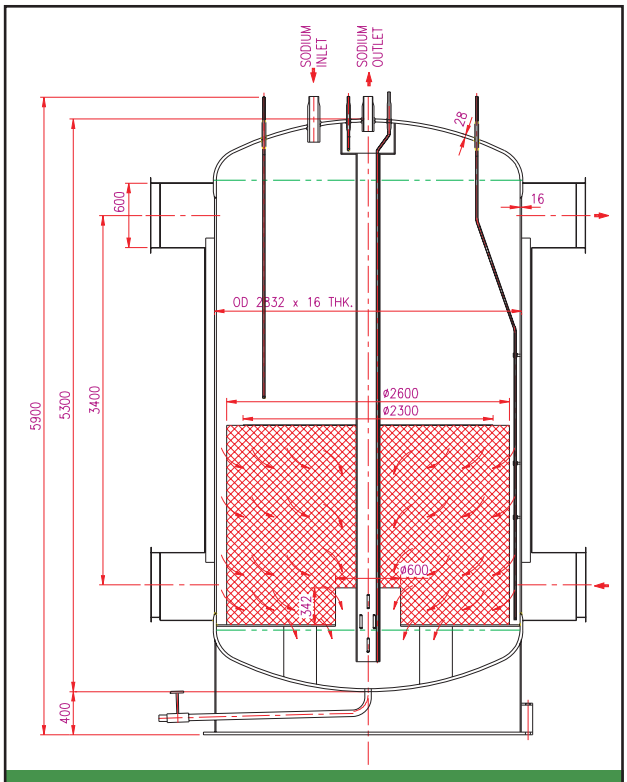

Figure 1: Present design for secondary cold trap

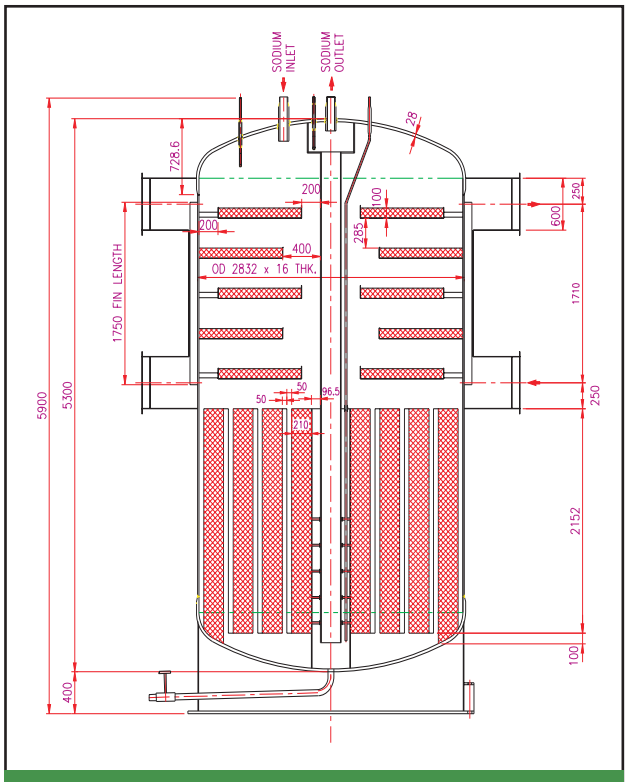

Figure 2: New design for secondary cold trap

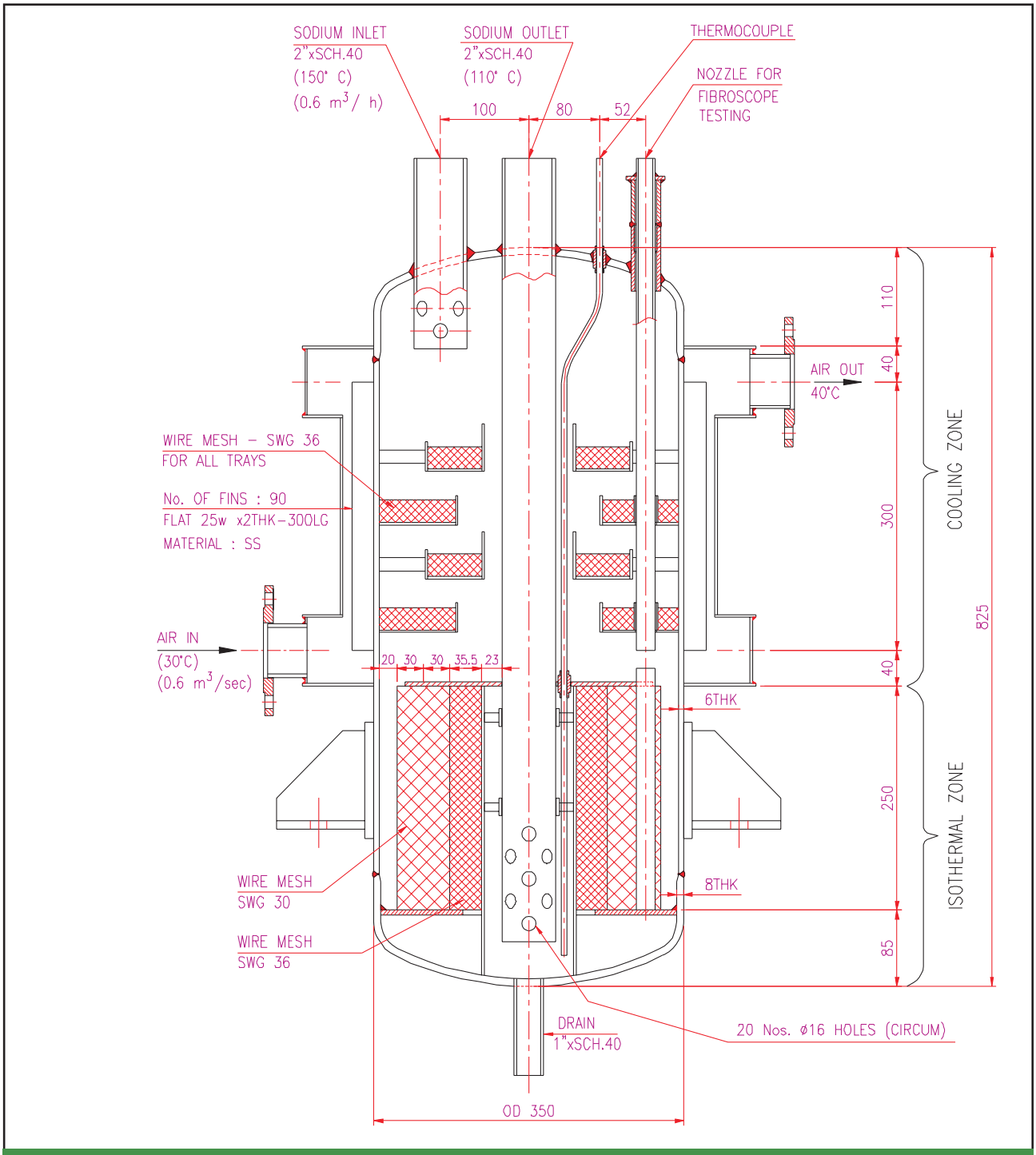

Figure 3: Model cold trap for experimental testing

hydrogen injection was measured. The experiment was continued till the amount of hydrogen injection reaches the 60% capacity of cold trap. It was found that the sodium flow through the model cold trap was not reduced. To assess whether all the hydrogen in the sodium gets trapped, measurements were carried out in the sodium in the loop. This data indicates that the model cold trap capacity reached nearly three times to that of the cold trap of existing design (compared to the present capacity 20%).

The model cold trap was subjected to neutron and X-Radiography. The hydride deposition could be clearly seen in the cooling zone (top trays) and also in the isothermal zone. This observation indicates that model cold trap was not fully loaded/saturated with sodium hydride impurities. Based on these radiography images, capacity of the new design cold trap can further be enhanced by 10-15%.

In this way, a new design of cold trap was evaluated and found to be performing well and can be used for the replacement of the cold trap for FBR and also for future FBRs.

(Reported by M.G. Hemanath and colleagues, FRTG)

Development of Ball-Indentation Test Technique for Mechanical Property Evaluation

Flow properties like yield strength, Ultimate Tensile Strength (UTS), work hardening exponent, etc. are widely used as basic design parameters of material strength. Tension tests, in which a standard specimen is subjected to continuously increasing uniaxial tensile load is an accepted test to evaluate flow properties for materials strength specifications. However, in situations, where there is a need to evaluate the mechanical properties of critical plant components without compromising its structural integrity, standard tensile tests cannot be used as it involves extracting large volumes of material for testing. Similarly, tension tests are practically not possible when there is a need to evaluate the property gradients across small and irregular welds/their heat-affected zones and in cases where only small volumes of samples are available like in a failure analysis or in a new alloy development.

The indentation test technique using spherical indenter is gaining considerable attention for such applications to evaluate flow properties from a very small volume of material in an almost non-destructive way. Ball-indentation testing involves multiple loading-unloading of a spherical indenter on a metallic sample at a single location. An indentation load-depth curve (Figure 1) similar to the load-displacement curve of the uniaxial tensile test is obtained from this procedure. This curve represents the deformation behaviour of the test material due to the indentation by a rigid ball indenter. The equivalent true stress and strain, identical to flow properties from a standard tensile test, can be estimated by analyzing the load-depth curve.

Developmental activities in this area at our Centre include (i) development of indigenous test equipments and fixtures for standardizing the test procedure and analysis methodology (ii) benchmarking and validating with conventional tensile test results (iii) demonstrating the potential applications of this technique (iv) understanding the deformation in indentation tests using finite element analysis.

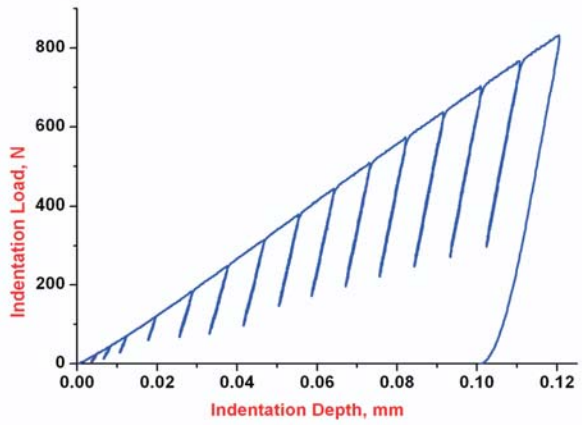

Figure 1: Typical load-indentation depth plot obtained for modified 9Cr-1Mo steel using 1 mm diameter tungsten carbide ball indenter

Indigenous development of miniature mechanical test systems for carrying out controlled multiple loading/unloading indentation tests was the first step towards mastering this technology. A servo-hydraulic test system and a ball screw driven electromechanical test system, each with loading capacity of 500 Kg and modular in design were devised (Figure 2). Both the test systems are equipped with a microprocessor based closed loop servo controller with provisions for carrying out cyclic indentation tests at user defined speeds with a Windows based Graphical User Interface (GUI) and real time data acquisition. The test systems are fitted with precision load cells of 200 Kg capacity and displacement sensor of ±0.25 mm range for accurate measurement of indentation load and depth respectively. Tungsten carbide balls of diameters ranging from 1-2 mm were chosen as indenter material.

Extensive trials have been carried out to standardize the ball-indentation test procedure on both the test systems. The servo-controllers were tuned to optimize the Proportional-Integral-Differential (PID) gains for smooth loading and unloading test cycles at various speeds ranging from 0.05 mm/min to 0.5 mm/min in both displacement and load controls. Starting with low carbon steel, ferritic steels like 2.25Cr-1Mo, modified 9Cr-1Mo steels and austenitic stainless steels like SS304 and SS316, the ball-indentation test procedures were standardized to establish a window of test parameters like the peak loads and maximum indentation depth with respect to sample dimensions and indenter diameter, number of loading-unloading cycles, rate of loading/unloading, extent of unloading etc. The analytical formulations developed using the fundamental understanding of the indentation deformation process was used to convert the load-depth data to stress-strain values. Some of the improvements in the analysis methodology, such as unloading curve analysis, including pile-up effects has led to improved accuracy of flow-curve analysis and tensile-property evaluation. Figure 3 shows the good matching of the stress-strain curve of ball-indentation tests with the corresponding tensile flow curve for the various materials studied.

Following this benchmarking exercise, the indentation technique has been put to use for some applications like (i) property gradients in weldments of modified 9Cr-1Mo steel (ii) for evaluating the thermal and creep damage in modified 9Cr-1Mo steels. The gradients in the tensile properties across the various heat affected zones of modified 9Cr-1Mo weldments obtained from the

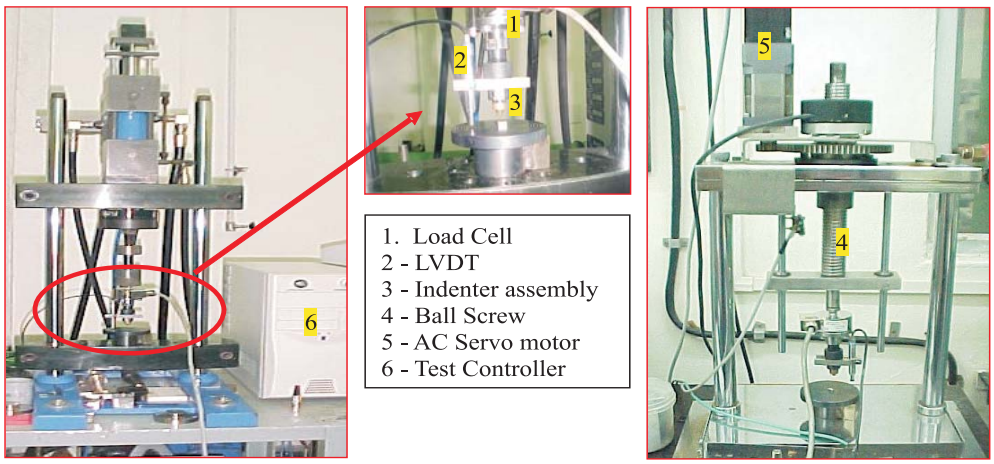

Figure 2: Table top mechanical test machines for carrying out ball-indentation test

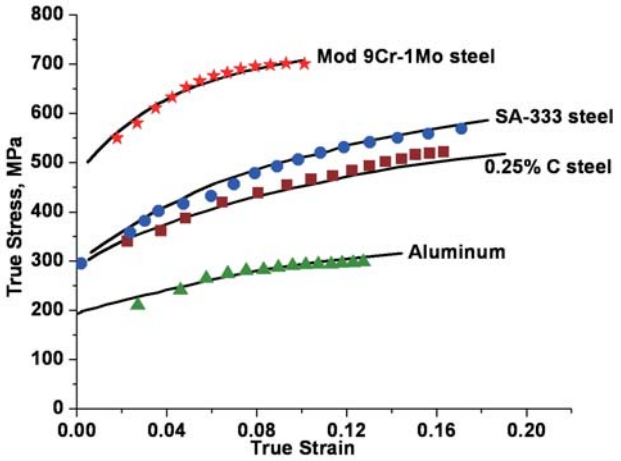

Figure 3 : Stress-strain plots from ball-indentation tests (dotted points) superimposed on the respective tensile stress-strain curves (represented by solid lines) for the various materials.

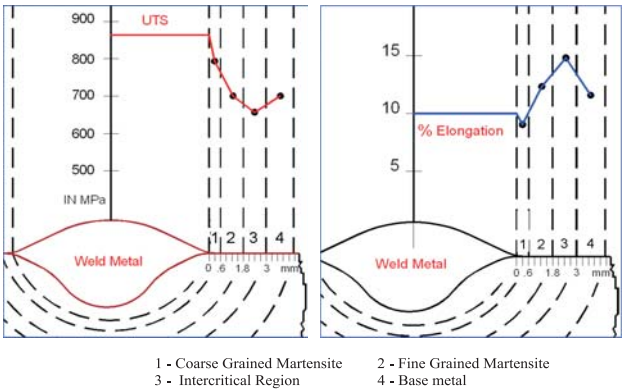

Figure 4 : Gradients in the strength and ductility across the heat affected zones of Mod 9Cr-1Mo weld joint

ball-indentation test technique are shown in Figure 4. Towards developing a life assessment methodology for aged components of modified 9Cr-1Mo, specimens have been artificially degraded by thermal aging and creep tests at 923K and the associated mechanical property changes are being studied using ball-indentation technique. Results indicate that ball-indentation technique can be a very useful indicator of the creep life expended for plant components made of ferritic steels. The other ongoing studies using ball-indentation technique include (i) mapping the tensile property changes of various service exposed steel components of Heavy Water Plant to examine the fitness-for-service (ii) characterizing the mechanical properties of bimetallic components fabricated through 'Laser Rapid Manufacturing technique' at RRCAT, Indore.

One of the potential application of ball-indentation technique currently being undertaken is mechanical property evaluation of irradiated SS316 wrappers of FBTR. Since the volume of material required is very small (~30 mm^3), small specimens of irradiated wrapper with greatly reduced levels of γ-radiation, can be handled with considerable ease outside the hot cells for mechanical property evaluation. This also requires developing a methodology for ball-indentation of cold worked materials like the FBTR wrapper which exhibits directional properties.

International groups working in this area are presently evolving a methodology for evaluating a fracture toughness parameter from indentation tests based on the concepts of indentation energy, using models of continuum damage mechanics.

Considering the various potential applications of the ball-indentation technology for non-destructive evaluation of mechanical properties of materials used in both nuclear and other power generating industries, a round robin exercise programme between various groups of BARC and IGCAR has been initiated. The aim of this exercise is to harmonize the testing and analysis procedures and ultimately evolve a standard code of practice for ball-indentation testing. The in-house expertise gained will be very useful for extending the ball-indentation test technique for non-destructive, quantitative measurement of mechanical properties of in-service structures using field equipments.

(Reported by V.Karthik, K.V.Kasiviswanathan, K.Laha and colleagues, MMG)

Young Officer's FORUM

Temperature Evolution in Top Shield during Partial Loss of Cooling in Raw Water Cooling System

Shri Hemant Kumar Patel, did B.E. in (Mechanical Engineering) from Hitkarini College of Engineering and Technology, Jabalpur, Madhya Pradesh in 2003. He has done his M.Tech. in (Fluid and Thermal Science) from Indian Institute of Technology, Kanpur in 2006. He is from 3rd DGFS batch of BARC training school and joined in IGCAR in Reactor Engineering Group in January, 2007.

Top shield of PFBR is a box type construction, filled with heavy density concrete and forms the top cover of the main vessel. It is exposed to sodium pool and argon cover gas at the bottom and reactor containment building environment at the top. It gets heated by natural convection of argon and by thermal radiation from sodium surface. To maintain its temperature at 393K, it is force cooled by air. The air in turn transfers the heat to service water in a separate circuit, which in turn transfers the heat to raw water which is air cooled in cooling towers. Cooling towers have four "Induced Draft Fans" (ID Fan) each of 33.3 % capacity and three at a time will be sufficient for 100 % heat removal during normal operation conditions (based on n-1 philosophy) (Figure 1). During the maintenance of one of the "Induced Draft Fan" under normal operation of the reactor, if one or more "Induced Draft Fan" of the remaining fails, then this would result in partial loss of cooling of the top shield. To estimate the time available to shutdown the reactor (in order to maintain the roof slab temperature within design limits or the time available to rectify and bring back the failed "Induced Draft Fan" in to operation) temperature change of the top shield in the case of partial loss of cooling has been analyzed.

A 1-D model of heat transfer from sodium free level to top shield through the cover gas by convection and radiation has been considered for study (Figure 2). Governing equation for the model has been derived from the heat balance for each part of the top shield i.e. thermal shield, bottom plate, jet plate, concrete, top plate, thermal insulation and cooling air. Sodium transfers heat to thermal shield by natural convection and radiation. Thermal shield, transfers heat to bottom plate through radiation and natural convection by the argon present in between. Bottom plate transfers heat to jet plate by radiation and to the cooling air by forced convection. Similarly the jet plate, concrete and top plate exchange heat with cooling air by forced convection and among themselves by radiation. The top shield cooling air comes through duct at temperature T_{a1} and takes heat from concrete-bottom, jet plate and bottom plate and gets heated to temperature T_{a2}. This heated air then passes through gap between concrete and the top plate and transfers the heat to concrete-top and top plate and leaves the top shield at a temperature $T_{a3.}$ The variation of

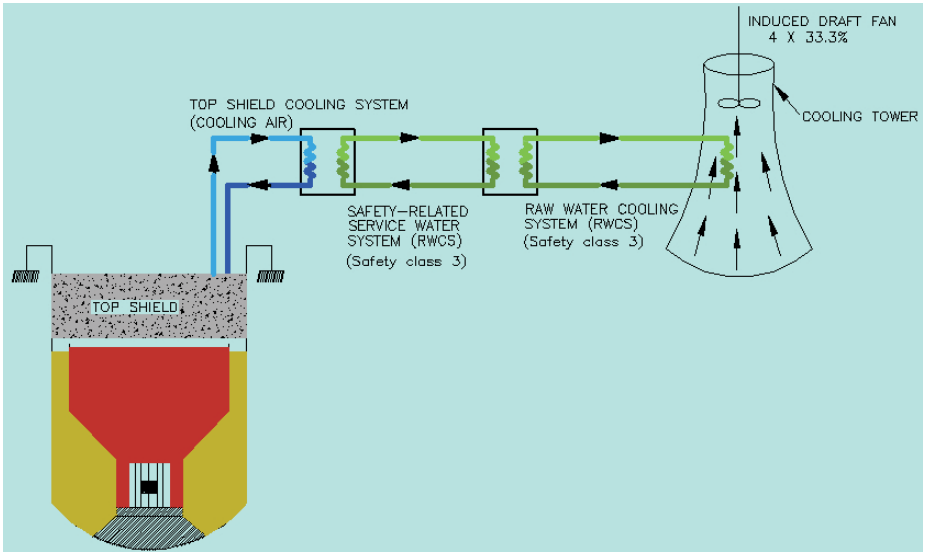

Figure 1 : Flow Diagram of heat removal system for top shield

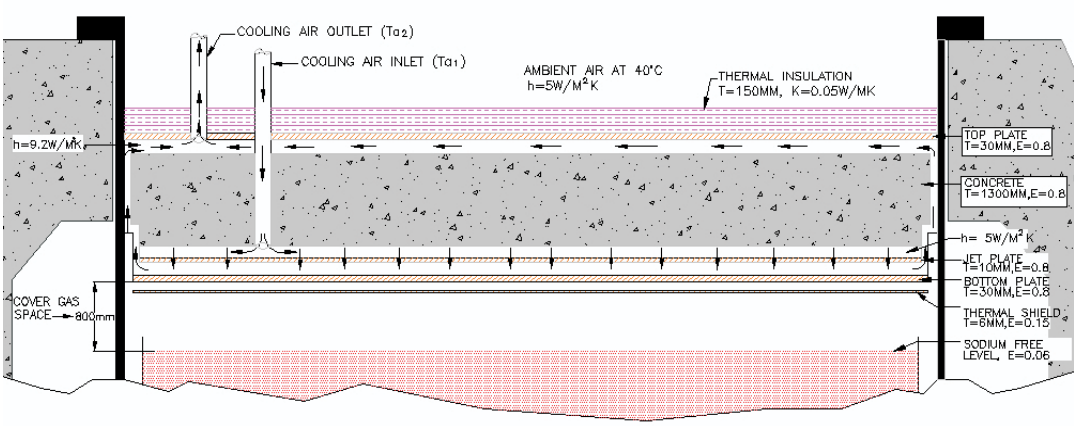

Figure 2 : Schematic representation of heat transfer model of Top shield

incoming cooling air temperature (T_{a1}) will depend upon the heat removal by the raw water system. A finite difference technique has been adopted to solve the governing equations.

To validate the model, a steady state condition with 100% cooling available was analyzed and the results are compared with previous studies. Temperature evolution of the roof slab in case of partial loss of cooling has been carried out for three different conditions of 66%, 33% and 0% cooling available. For the condition one: One out of three "Induced Draft Fans" failure (66% cooling available), the evolution of temperature has been predicted assuming a constant temperature of 820K for sodium and heat removal from the cooling air being reduced to 2/3. Results show that the temperature of the bottom plate reaches a value of 473K in about one hundred and fifteen hours (~ 4.8 days) (Figure 3). This is the time available for the operational personnel to plan and replace the defective "Induced Draft Fan". The temperature difference between bottom and top plates goes up to a maximum of twenty three degree after six hours and starts falling gradually.

For condition two: Two out of three "Induced Draft Fans" failure (33% cooling available), all the conditions being the same as in the previous case except that the heat removal from the cooling air being reduced to 1/3 instead of 2/3. The temperature of the bottom plate reaches a value of 473K in about thirty seven hours (~ 1.6 days) (Figure 4). For condition three: All the three "Induced Draft Fans" failure (0% cooling available), the temperature

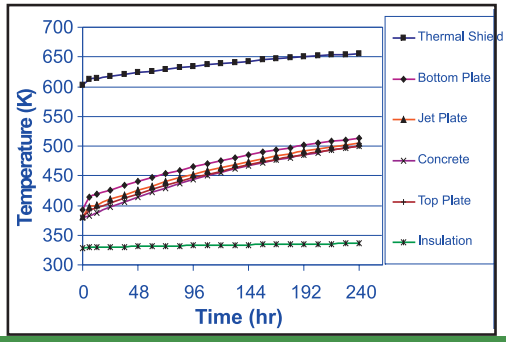

Figure 3 : Evolution of temperature of roof slab (one out of three "Induced Draft Fans" have failure)

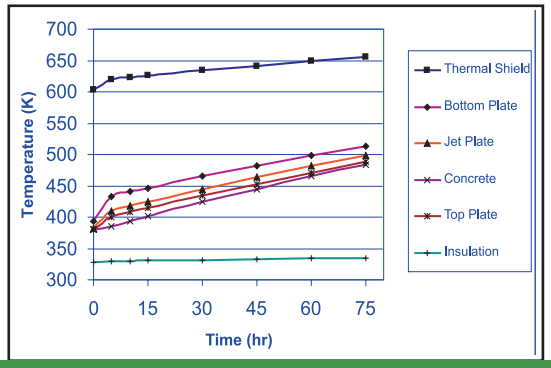

Figure 4 : Evolution of Temperature of roof slab (two out of three "Induced Draft Fans" failure)

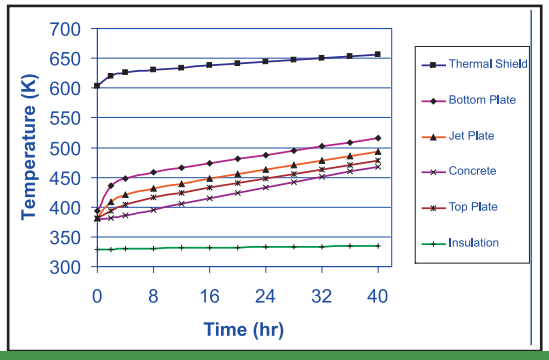

Figure 5 : Evolution of Temperature of roof slab (all the three "Induced Draft Fans" failure)

of the bottom plate reaches 473K in about 15.6 hours (Figure 5).

In summary, the analysis was carried out for three transients: 66 %, 33 % and 0 % cooling availability. The time available for operator to resume the cooling was found to be one hundred and fifteen hours, 37 hours and 15.6 hours respectively. In all the transients, the limiting parameter is found to be the maximum temperature of the bottom plate (473K). The temperature difference between the bottom and top plates is found to be within the permissible limits. This study has indicated that considerable time is available for the plant personnel to take necessary actions in the case of failure of "Induced Draft Fans" in the raw water cooling circuit.

(Reported by Hemanth Kumar Patel and colleagues, REG)

Young Researcher's FORUM

Cryptology of Synchronous Stream Ciphers

Shri Prasanth Kumar Thandra obtained his masters degree in physics from KGRL college, Bhimavaram, Andhra University in 2004. He joined as JRF in Computer Division, IGCAR in January, 2006. This work was initiated while he was JRF. This work led to filing a patent. He is presently a Scientific Officer in Computer Division, EIG and working on designing and analysis of encryption algorithms.

Electronic communication and electronic storage are growing rapidly to replace their traditional methods. Information is getting digitized and being exchanged over insecure channels like internet. In many cases data being exchanged is very valuable like passwords, credit-card numbers, bank transactions etc. This rapid growth of electronic communication necessitates higher information security. Data exchanged over these publicly accessible networks must be confidential and protected against modification. As many collaborative projects are in progress between different units of DAE, lot of information is being exchanged between them over the internet. As the information is highly sensitive in most of the cases, ensuring the confidentiality of the information is very important. Encryption is the most widely accepted solution for ensuring confidentiality. The current project undertaken is towards development of proprietary encryption algorithm that will be used among the DAE units. "Cryptology", the art of making and breaking of codes, is playing a major role in doing so. "Cryptography" is making-of-codes and "Cryptanalysis" is breaking-of-codes. Objectives of cryptography are mainly

Confidentiality	-	making data readable to authorized users only
Data integrity	-	checking whether data is modified or not
Authentication	-	identifying the source of the data
Non- repudiation	-	not able to deny the data transaction

Of these, our focus is mainly on "Confidentiality" and is achieved through encryption methods. There are different types of encryption methods but our work focused on cryptography and cryptanalysis of "Synchronous Stream Ciphers". Synchronous Stream Ciphers (SSC), in addition to block ciphers, are a category of symmetric encryption methods and preferred in hardware-restricted environments like smartcards as well as when fast encryption is required.

Cryptography of Synchronous Stream Ciphers

"Synchronous stream ciphers" encrypt a bit or few bits of message every time. It generates a key-stream of the length of the message, which has to be encrypted or decrypted, and XOR it with the message. Synchronous Stream Ciphers comprising of initialization phase and a key-stream generator. The generator in its i^{th} round generates an output key-stream, k_i, in both encryption and decryption. During encryption output, k_i is XOR with plain-text, Pt_i, to generate corresponding cipher-text, Ct_i. During decryption, Ct_i is XOR with k_i to get Pt_i.

The key-stream generator is initialized by a secret key, K, and initialization vector, IV. The core of key-stream generator is shown in Figure 1. It comprises an internal-state S_t, output function g, and an update function f. In every round of key-stream generator, g computes the output k_t as a function of S_t and f updates S_t as S_{t+1}. In this manner, all the output key-streams and internal states connected to each other as in equation (1).

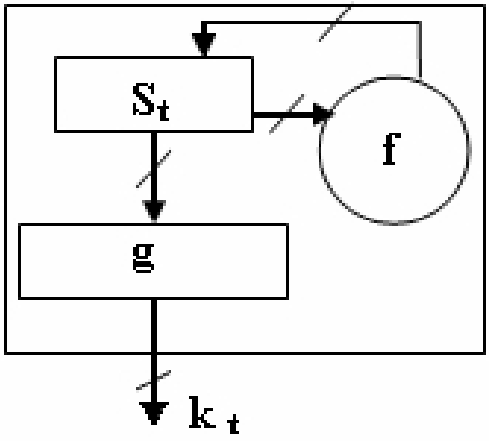

Figure 1 : The Key-stream generator

$$\left.\begin{aligned} K_0 &= g(S_0); \\ K_1 &= g(S_1) = g(f(S_0)) \\ K_2 &= g(S_2) = g(f^2(S_0)) \\ &\cdot\cdot \\ &\cdot\cdot \\ K_n &= g(S_n) = g(f^n(S_0)) \end{aligned}\right\} \quad (1)$$

A good "Synchronous Stream Ciphers" design involves the designing of nonlinear functions *g* and *f* because high nonlinearity decreases efficiency and low nonlinearity decreases security of the cipher.

In general, cryptographers believe that stream ciphers are not as secure as block ciphers. We noticed that most of the problems with "Synchronous Stream Ciphers" are involved with the set(1) i.e. the way key-stream generator goes from one state to another state. This is allowing the attackers to construct equations to solve them by exploiting some weakness in the design of *g* and *f*. As all these equations hold good with correctness probability of one, correctness of the set and the result obtained, through shortcut-attacks, is also "one". To improve the resistance of "Synchronous Stream Ciphers" against these shortcut-attacks, we aimed to modify the design, i.e. the way key-stream generator moves from one state to another state, so that the correctness of the set(1) for the resulting design should decrease with the number of equations in the set. We modified the design by taking the following points into consideration :

a) not encourage side channel attacks
b) compatible to restricted hardware environment
c) very efficient and small code size
d) capable of using parallel processing

With an approach of multi-core, parallel arrangement, a random selection between the cores and some specific choices, we achieved a new design for key-stream generator of "Synchronous Stream Ciphers". We constructed test-algorithms using the existing algorithms to test the resistance of design against shortcut attacks. When the method was tested with "Bluetooth" stream cipher and "Sober-t32", success probability of attacks decreased drastically to $(1/2)^{k+3}$ and $(1/2)^m$ from "1". Where, $k=2^{23.07}$ and $m=2^{60}$ are the number of output key-streams or set of equations required to implement the original attacks. Results of test-algorithms showed that, the new design is very strong against attacks require set(1) with number of equations in the order of size of the key and above. But, 99% of the attacks on "Synchronous Stream Ciphers" require set(1) with number of equations in the order of 2^{20}. An example flowchart of the scheme is shown in Figure 2.

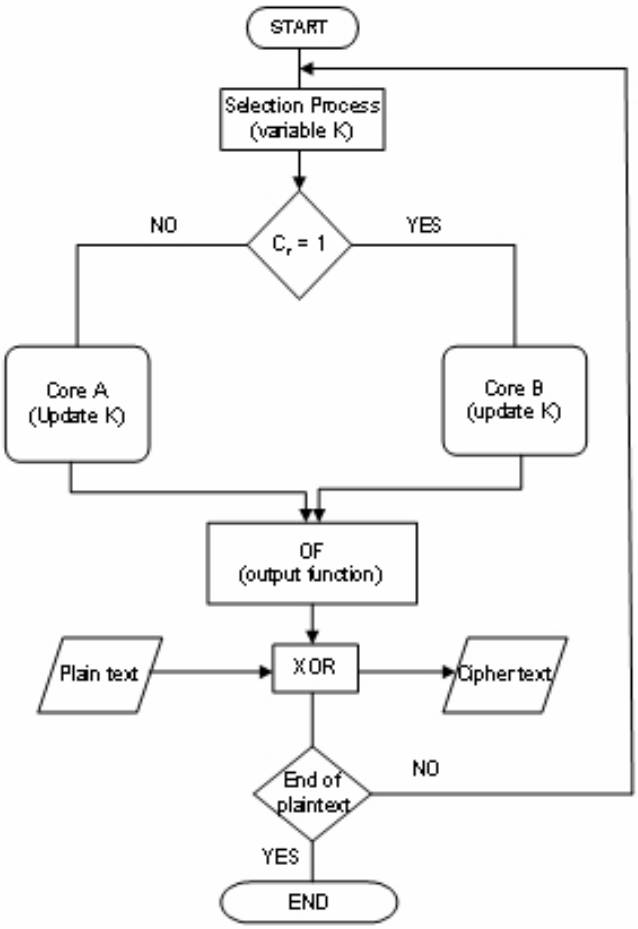

Figure 2 : Flowchart of the new design

We implemented the method for block ciphers and found that the impact of modification was low when compared with "Synchronous Stream Ciphers".

Cryptanalysis of Synchronous Stream Ciphers

Cryptanalysis of Synchronous Stream Ciphers can be divided as:

Shortcut attacks - uses set(1) based on weaknesses in *g, f*

Side-channel attacks - uses information like power signatures, time consumption to attack

As a part of developing and testing secure "Synchronous Stream Ciphers", we concentrated on both type of attacks. HENKOS is a "Synchronous Stream Ciphers" proposed in the year 2004 and claimed as a secure cipher with no weaknesses. The algorithm contains three components, 256 bytes in length, a secret key MK, an IV or data-key (DK) and transformation of master key is initialized (MK) is as follows:

$$MKT_i = \text{mirror}\,[(\Sigma_{j=0..i} MK(j)) \%256)] \%256, \text{ for } i = 0..255; \quad (1)$$

Where, mirror of 255 is 552. Initialization of Data Key involves sixty four rounds of recursive operations of switch function (SW or t) and additive function (AD or f) to result first internal-state S_0.

$$\left.\begin{array}{l} DK_j \longleftrightarrow DK_k\ ; \\ \text{where, } j = MK_i \text{ and } k = MKT_i;\ i = 0..255; \end{array}\right\} \text{SW} \quad (2)$$

$$\left.\begin{array}{l} DK_i = DK_i + DK_{i+1} \text{ modulo } 256 \quad i = 0...254; \\ DK_{255} = DK_{255} + DK_0; \end{array}\right\} \text{AD} \quad (3)$$

$$\text{then the output key-stream } Z_i = S_i \text{ XOR } t(S_i)\ ; \quad (4)$$

Attacks on HENKOS

In a chosen IV attack, attacker uses IV of his choice and tries to achieve the knowledge over either the plain-text or the bits of secret key.

Choose an IV with the values of individual bytes zero. For this IV, value of t(DK), f(t(DK)) (say f.t =h) and h^{64}(DK) are shown in Figure 3, irrespective of the choice of MK. This shows the output key-stream values to be always zero at any round of HENKOS. Hence, in this case both plaintext and cipher-text are same.

Weak keys

Weak keys are those with which an algorithm becomes insecure. We found different groups of weak keys.

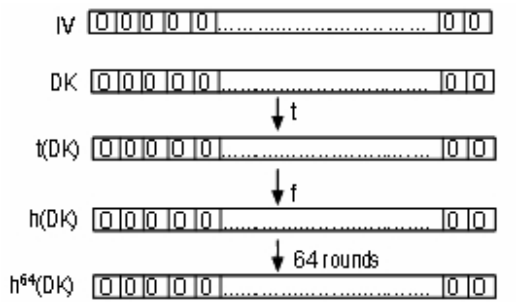

Figure 3 : Chosen IV attack on HENKOS

Property of all these groups is that "members of these groups make the t function inefficient". As a result, key-stream generated by HENKOS will always be a sequence of "ZEROs". One such set has the keys with

a) values at all indices set to ZERO except any one odd index

b) value at the odd index belongs to the set called "symmetry"

$$\text{Symmetry} = \{000,010,020,.....,090,\ 101,111,121,.....,191,\ 202,\ 212,\ 222,...,\ 252\} \quad (5)$$

Represent a member of the set as $MK^{(L,M)}$ where *L* belongs to "symmetry" and M the odd index chosen. $MK^{(222,\ 253)}$ and its MKT are in Figure 4. This pair makes the *t* function ineffective, resulting the cipher-text to be identical to plain-text. These attacks showed that the stream cipher HENKOS is not secure and strong encryption schemes are required to encrypt the data to prevent them from leaking information to unauthorized people.

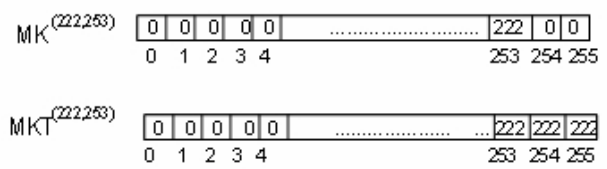

Figure 4 : Arrays $MK^{(222,253)}$ and $MKT^{(222,253)}$

As the world is getting more and more connected, data transfer over insecure networks is increasing day-by-day. Ensuring security of their information has become essential for both organizations and individuals. Study and implementation of cryptographic aspects plays an important role in implementing data security.

(Reported by Prasanth Kumar Thandra, Computer Division, EIG)

NEWS AND EVENTS

BITS Practice School

Shri S.C. Chetal, Director, REG with students from BITS Practice School along with senior colleagues of IGCAR

Twenty four students from BITS Pilani (Pilani and Goa campuses) underwent BITS Practice school for seven weeks at our Centre. Dr.Baldev Raj inaugurated the BITS practice School at IGCAR on May 26, 2008 along with the STIPAC courses. The BITS practice school bridges the professional world with the educational world. The course aims at exposing the students to industrial and research environments, on how the organizations work, to follow and maintain work ethics, study the core subjects and their application in the organization, participate in some of the assignments given to them in the form of projects. The students were from various Engineering disciplines namely, Mechanical Engineering, Electrical & Electronics Engineering, Electronics & Instrumentation Engineering, Computer Science Engineering and other disciplines like Mathematics, Physics and Economics. Students carried out challenging projects from various divisions in line with their discipline. During the period of their stay they visited various facilities at IGCAR, BHAVINI and MAPS. Group discussions, seminars, project work presentation and report writing formed the practice school curriculum. On completion of the practice school, Shri S.C.Chetal Director REG, had an interaction session with the students and distributed certificates to the students.

(Reported by M. Sai Baba, Coordinator-BITS Practice School)

Summer Training Programme in Physics and Chemistry (STIPAC 2008)

Students of Summer Training Programme in Physics and Chemistry with Dr. Baldev Raj, Director, IGCAR and other colleagues

A summer Training Programme in Physics and Chemistry for the year 2008 (STIPAC-2008) with a theme focused on "Physics and Chemistry of Nanomaterials" got up to a jubilant start with Dr. Baldev Raj, Director, IGCAR inaugurating the programme on May 26, 2008. During the inaugural session Dr. Baldev Raj exhorted the students to undertake science and technology based research career to build a stronger scientific frontier that would effectively counter several challenging problems bordering environment and energy. This years programme, in which nineteen students from physics and twenty students from chemistry participated, continued till July 4, 2008. Although the theme was on nanomaterials, the core areas of physics and chemistry were covered by experts in the respective fields including introductory lectures on nuclear reactors. In the afternoon hours the students were imparted hands on experience through project work. In order to enthuse the student participants to take up a career in science, special lectures by eminent educationalists and scientists from leading institutes were arranged. STIPAC 2008 had an interesting additional feature, viz., two lectures that were delivered by former STIC students.

The valedictory function held on July 4, 2008 and was presided over by Dr. P. R. Vasudeva Rao, Director, Chemistry, Metallurgy & Materials Groups who emphasized the need for synergy between physics and chemistry in the context of nanotechnology. Prof. P. T. Manoharan, Chief Guest of the function dwelt on some interesting and current research on nanotechnology and distributed the certificates to the students.

(Reported by V. Jayaraman and Sitaram Dash, Course Directors, STIPAC 2008)

Graduation Function of the 2nd Batch of BARC Training School at IGCAR

Dr. P.S.Goel, President, INAE and former Secretary, Department of Earth Sciences, Dr.Anil Kakodkar, Chairman, Atomic Energy Commission & Secretary, Department of Atomic Energy, Dr.Baldev Raj, Director, IGCAR during the Graduation Day

The graduation function of the 2nd batch of BARC Training School at IGCAR was held on August 30, 2008 at Sarabhai Auditorium, Homi Bhabha Building, IGCAR. Forty five trainees graduated after successful completion of their training. Dr. P.S. Goel, President, Indian National Academy of Engineering and former Secretary, Department of Earth Sciences graced the occasion as Chief Guest and Dr. Anil Kakodkar, Chairman, Atomic Energy Commission & Secretary, DAE presided over the function.

Dr. M. Sai Baba, Head, Strategic and Human Resources Planning Section and Head, BARC Training School at IGCAR welcomed the gathering. Dr. Baldev Raj, Director, IGCAR addressed the gathering. A souvenir featuring the 2nd year of the training programme at IGCAR was released by Dr. Anil Kakodkar and Dr. P.S. Goel received the first copy. In his address Dr. Anil Kakodkar mentioned that human resources development is the most important activity in DAE. He mentioned that Training School program was also bringing the people together from varied backgrounds and binding them together as a family. Some of the Trainee Scientific Officers from 2nd batch voiced their feedback about the courses and their stay at the hostel. Dr. P.S. Goel gave away the prestigious 'Homi Bhabha Prize' to the meritorious toppers from each of the disciplines. He also gave away the course completion certificates to all the graduates passing out. Dr. P.S. Goel also gave away the course completion certificates to "Operation and Maintenance Trainee Scientific Officers" of BHAVINI who have successfully completed their training at BARC Training School at IGCAR. Dr. P.S. Goel addressed the gathering with a very inspiring and thought provoking lecture highlighting the aspects of global warming and emphasized the need for scientists and engineers to work together to achieve breakthroughs. Dr. Vidya Sundararajan, S&HRPS proposed the vote of thanks.

(Reported by M. Sai Baba, BARC Training School @ IGCAR)

Second Batch of Graduates of BARC Training School at IGCAR with the Chief Guest Dr. Anil Kakodkar, Chairman, AEC, Dr. Baldev Raj, Director, IGCAR, senior colleagues of the Centre

World Environment Day Celebrations - WED 2008

Dr. Baldev Raj, Director, IGCAR. and Dr.R.V.Sharma, Deputy Director General, India Meteorology Department with the Chancellor SRM University and other dignitaries at WED 2008 Celebrations

One day National Workshop on 'Environmental Sustainability' was organized at SRM University on June 5, 2008 coinciding with the World Environment Day. Dr. Baldev Raj, Director, IGCAR inaugurated the workshop and delivered the keynote address. Experts from various academic and research institutes deliberated on issues related to climatic change & biodiversity, atmospheric dispersion studies for gaseous effluents, nanotechnology & environment, biomedical & E-waste management, atmospheric pollution and its effects, bio mimicry lessons to learn from the environment etc. The participants included scientists from research and academic institutions, practicing engineers and NGOs. The workshop involved technical presentation by the researchers of the University. Dr.H.S.Kushwaha, Director, Health Safety & Environment Group, BARC gave the valedictory address. Researchers of the University made technical presentations to Dr. Baldev Raj, Director, IGCAR, which was followed by his visit to the research facilities.

National Awareness Seminar on 'Nano Science and Technology'

One day National Seminar on "Nano Science and Technology – Challenges Ahead" was organized at Velammal Engineering College, Chennai on August 19, 2008 to enhance the awareness on the emerging Nano Science & Technology among the potential young minds and stimulate their curiosity to take-up scientific research as their career. A dedicated poster-session organized for the student-researchers was well received. Dr. Baldev Raj, Director, IGCAR steered and guided the conduct of the Seminar as the Chairman of its National Advisory Committee. Dr.A. K. Tyagi, Head, Surface Science Section, Material Science Division, IGCAR spoke on 'Nanotechnology for Nuclear Applications'. Dr. K.Ranga Rao, Indian Institute of Technology, Madras, Dr.P.T. Perumal, Director Grade Scientist, Central Leather Research Institute, Chennai, Dr. Nammalvar Gopalakrishnan, National Institute of Technology, Tiruchirapalli and Dr. S.Sivanesan, Anna University, Chennai deliberated on 'Synthesis and Characterisation of Nanomaterials', 'Reaction with Carbon Nanotubes and Synthesis of Heterocycles', 'Group III-Nitrides doped ZnO Nanostructures' and 'Nanomaterials in Environmental Applications'. Shri. N.Kalyanasundaram, Joint General Manager, Thirumalai Chemicals distributed the certificates to the best paper winners during valedictiory function.

Radiation Awareness Programme at Indian Institute of Science, Bangaluru

IGCAR participated in the "Mrs. Mrudula Vaidya Memorial Inter-School Event -2008" organized on the theme 'Atoms for Peace' at Indian Institute of Science, Bangaluru for the Kendriya Vidyalaya students from Bangaluru and its neighborhood on August 29, 2008. IGCAR organized an exhibition on radiation detection, measurement, monitoring, and Safety aspects, India's three stage nuclear power programme etc. Dr.V.Meenakshisundaram, Head, Radiation Safety Section, safety Group, IGCAR, delivered a lecture on 'Nuclear Energy - Sustainable and Environmental Friendly Option'. A quiz on "Nuclear Science" was conducted by Dr. S.Venkadesan, Chief Librarian, Indian Institute of Science. Shri. S.Vijayakumar, Assistant Commissioner, Kendriya Vidyalaya Sangathan, Bangaluru Region and Dr.Renee M.Borges, Centre for Ecological Sciences, Indian Institute of Science graced the occasion.

(Reported by J. Daniel Chellappa and P.V. Ramalingam, Public Relations Activities Implementation Committee, IGCAR)

Conference / Meeting Highlights

SANGOSHTHI - 2008

July 24-26, 2008

Dr. Baldev Raj, Director, IGCAR, Shri Prabhat Kumar, Chairman, LISPS and Project Director, BHAVINI, Prof. E. Balagurusamy, Member, UPSC, New Delhi, Dr. S. P. Garg, former Associate Director, Knowledge Management Group, BARC and Dr.T.S.Rao, Secretary, SANGOSHTHI 2008 during the inauguration

Library & Information Science Promotion Society (LISPS) in association with Indira Gandhi Centre for Atomic Research (IGCAR) and other DAE units at Kalpakkam. organized a three day conference, Sangoshthi - 2008 during July 24-26, 2008 on "Role of IT-Enabled Knowledge Management in Growth of India". The conference was inaugurated by Prof. E. Balagurusamy, Member, UPSC, New Delhi in the gracious presence of Dr. Baldev Raj, Director, IGCAR, Shri Prabhat Kumar, Chairman, LISPS and Project Director, BHAVINI, and Dr. S. P. Garg, former Associate Director, Knowledge Management Group, BARC, Mumbai.

Dr. Baldev Raj, in his inaugural talk, stressed on the necessity of knowledge sharing and the need to ensure the sustained growth of agriculture for the growth of India. He also emphasized the need to change the education system, so that students opt for different professions, in addition to currently preferred in the areas of Engineering and Medicine. Prof. E. Balagurusamy in his keynote address emphasized the importance of knowledge for the social and economic development of the country. Though India is number one in producing IT professionals and IT Enabled Services, it is at ninety nine position in the usage of Information Technology. He reiterated for a sea change in IT enabled governance to bring intelligibility in government functioning. Dr. S.P. Garg, gave the keynote address highlighting the BARC Training School as system of preserving and propagating knowledge. The experienced scientists and engineers of the department transfer their knowledge to the trainees.

The Conference ended with closing remarks from Shri Prabhat Kumar, who stressed the need of Knowledge Management in Projects like PFBR, where a large number of people had to contribute. He also stressed knowledge sharing between agencies like Research & Development, construction, operation & maintenance etc. are very vital for any organization.

(Reported by T.S. Rao, Secretary, SANGOSHTHI 2008)

Science and Engineering Research Council School on Chemical Thermodynamics (CHEMTHERM 2008)

August 18-23, 2008

A Science and Engineering Research Council (SERC) School on Chemical thermodynamics (CHEMTHERM 2008) was conducted during August 18-23, 2008 at IGCAR with full financial support from the Department of Science & Technology. The primary objective of CHEMTHERM 2008 was to enthuse and nurture researchers from academia to take up challenging problems in chemical thermodynamics. Among fifty applicants, twenty five were chosen consisting of many faculty members and young researchers. The inaugural session was presided over by Dr. P.R. Vasudeva Rao, while Dr. S.V. Narasimhan formally inaugurated this workshop. This workshop turned out to be truly a national meet for it comprised of participants from many states including Jammu-Kashmir, Gujarat and Orissa. Lectures were delivered on many topics highlighting the utility of experimental thermodynamics. These included the following: measurement of vapour pressure & emf, determination of phase diagrams, thermodynamic modeling, generation, measurement of high temperatures etc. Senior thermodynamicists from BARC, IGCAR and professors from IIT Madras, IIT Mumbai delivered many instructive lectures. The effectiveness of this SERC School was assessed by having two feed back sessions one in the midst and the other at the end. In order to provide a flavour of the practical utility of experimental thermodynamics, a visit to laboratories in IGCAR was arranged for the participants. The lecture material in the form of a CD and an advanced text book on chemical thermodynamics were distributed to all the participants.

Participants of the CHEMTHERM 2008 workshop with Dr. P.R. Vasudeva Rao, Director, CG & MMG, Dr. S.V. Narasimhan, Associate Director, CG, BARC, and Head, WSCD, BARC(F) and other senior colleagues of the Centre

(Reported by K. Ananthasivan, Secretary, CHEMTHERM 2008)

5th International Conference on Creep, Fatigue and Creep-Fatigue Interaction (CF-5)

September 24-26, 2008

Dr. Farhad Tavassoli , Head, Fusion Materials Project, CEA, France inaugurating CF-5.
Seated from left to right are Dr. Baldev Raj, Director, IGCAR, Dr. Yukio Takahashi, Central Research Institute of Electric Power Industry, Tokyo, Japan and Dr. M.D. Mathew, Convener, CF-5

The Fifth International Conference on Creep, Fatigue and Creep-Fatigue Interaction (CF-5) was held at IGCAR, during September 24-26, 2008. The conference was organized jointly by IGCAR and The Indian Institute of Metals, Kalpakkam Chapter and the Metal Sciences Division of Indian Institute of Metals.

Dr. Farhad Tavassoli, Head, Fusion Materials Project, CEA, France, inaugurated the conference. The inaugural function was presided over by Dr. Baldev Raj, Director, IGCAR and Chairman of the National Organizing Committee. Dr. Yukio Takahashi, Central Research Institute of Electric Power Industry, Tokyo, Japan represented Japan Society of Mechanical Engineers and The Society of Materials Science, Japan at the inaugural function.

Fifty two invited papers and nearly one hundred contributed papers were presented in the three-day conference. The technical sessions consisted of one plenary session and eighteen parallel sessions. The sessions were structured such that there were many presentations dealing with Creep and Fatigue Issues in High Temperature Materials Development and Design, Low Cycle Fatigue and Thermo Mechanical Fatigue, Creep Mechanisms and Creep Resistant Alloys, Creep-Fatigue Interaction, Remaining Life Assessment, Ferritic, Martensitic Steels, Materials Design and Development, Creep-Fatigue and Design, Fretting fatigue and High Cycle Fatigue, Structural Integrity Analysis, Creep and Fatigue of Welds and Innovative Testing Methods for Creep and Fatigue, Creep and Fatigue Life Prediction, Superalloys, Fracture Toughness and Crack Growth, Zr Alloys and Ti Alloys, Coatings and Composites, Failure Analysis.

More than two hundred and fifty delegates including thirty eight delegates from eight countries attended the conference. About thirty masters and doctoral students were invited as delegates from abroad to enable them to derive benefit from the technical deliberations of CF-5.

CF-5 was sponsored by the Board of Research in Nuclear Sciences, DAE, and was co-sponsored by the Japan Society of Mechanical Engineers and The Society of Materials Science, Japan.

CF-5 was supported by Atomic Energy Regulatory Board, Board for Research in Fusion Science and Technology, Council of Scientific and Industrial Research, Department of Space, Department of Science and Technology and Defense Research & Development Organization.

(Reported by M.D. Mathew, Convenor and K. Bhanu Sankara Rao, Chairman, Local Organising Committee, CF-5)

IGCAR-CEA Workshop on Materials and Design Issues for Fusion and Fission Reactors

September 23, 2008

Participants of IGCAR-CEA workshop with Dr. Baldev Raj, Director, IGCAR, and senior colleagues of the Centre

A one-day workshop on "Materials and Design Issues for Fusion and Fission Reactors" was organized at IGCAR on September 23, 2008 with participation from members of IGCAR and CEA, France. Dr. Baldev Raj, Director, IGCAR welcomed the participants and gave a perspective on fission and fusion energy in the Indian context. Dr. Farhad Tavassoli, Head, Fusion Materials Project and leader of the CEA delegation, gave an overview of the collaborations of CEA with IGCAR. There were presentations by members from IGCAR and CEA. Presentations from IGCAR were made by Shri R.Srinivasan, Nuclear Engineering Group, REG on "Heat Exchanger Design & Analysis as per RCC-MR" and Dr.K.Bhanusankara Rao, Associate Director, Materials Development and Characterisation Group, MMG on "A Comprehensive View of Dynamic Strain Ageing aspects in High-Temperature Fatigue". Presentations from CEA were made by, Dr.Philippe Billot on "Synergy of Fission-Fusion in Materials", Dr. Christian Robertson on "Effect of Mean Stress on Micro-crack Initiation" and Dr. Olivier Ancelet on "Developments in CEA on Defect Assessment, Structural Integrity and Life Time Evaluation".

IGCAR-KAERI Workshop on High-Temperature Materials, Design and Assessment

September 29, 2008

Participants of IGCAR-KAERI workshop during discussion with Dr. Baldev Raj, Director, IGCAR, and senior colleagues of the Centre

A one-day workshop on "High Temperature Materials, Design and Assessment" with participation from IGCAR and Korean Atomic Energy Research Institute (KAERI) was held at IGCAR on September 29, 2008. Dr. Baldev Raj, Director, IGCAR, welcomed the participants and Dr.Woo-Seog Ryu, leader of the KAERI delegation responded. There were presentations by members from IGCAR and KAERI. From IGCAR, Shri S.C.Chetal, Director, REG spoke on "Design of PFBR", Dr. P.Chellapandi, Director, SG and Associate Director, Nuclear Engineering Group, REG on "Qualification of Components for Design of FBR Components", Dr.M.D.Mathew, MMG on "Creep Properties of Structural Materials" and Dr. K.Bhanusankara Rao, Associate Director, Materials Development and Characterisation Group, MMG on "Low-cycle Fatigue & Creep-Fatigue Interaction Behaviour of FBR Components". The presentations from KAERI were made by Dr.Woo Seog Ryu on "R&D Status of Very High Temperature Reactor(VHTR) Materials", Dr.Hyeong Yeon Lee on "Assessment of Damage and Crack Behaviour of High Temperature Components", Dr.Woo Gon Kim on "Methodologies to Predict Long-term Creep Life of Stainless Steel" and Dr.Dae Whan Kim on "Evaluation of Mechanical Properties of Structural Materials".

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

Visit of Dignitaries to IGCAR

Shri Jayaram Ramesh, Hon'ble Minister of State for Commerce and Power, Government of India during discussion with Dr.Baldev Raj, Director, IGCAR, Shri S.K.Jain, Chairman & Managing Director, Nuclear Power Corporation of India Limited and other senior colleagues of DAE units at Kalpakkam

Shri Jayaram Ramesh, *Hon'ble Minister of State for Commerce and Power*, Government of India, visited the Centre on July 12, 2008 and held discussions with Dr.Baldev Raj, Director,IGCAR, Shri S.K.Jain, Chief Managing Director, NPCIL and other senior colleagues from various units of DAE. Director, IGCAR made a presentation on the status of Fast Reactor and Associated Fuel Cycle Technologies. Shri Jayaram Ramesh had an informal and lively interaction with Trainee Scientific Officers and Research Scholars.

Shri Jayaram Ramesh, Hon'ble Minister of State for Commerce and Power, Government of India, Dr.Baldev Raj, Director, IGCAR, Shri S.K.Jain,CMD, NPCIL and other senior colleagues from BHAVINI during interaction session with Trainee Scientific Officers and Research Scholars

Air Marshal Shri S.C.Mukul, Commanding-in-Chief of Southern Command and other officers from Air Force Station holding discussion with Dr.Baldev Raj, Director, IGCAR and other senior colleagues of DAE Units at Kalpakkam

Commanding-in-Chief of Southern Command **Air Marshal Shri S.C.Mukul** visited the Centre on August 6, 2008. He was accompanied by other officers from Air Force Station. He held discussion with Dr.Baldev Raj, Director, IGCAR and other senior colleagues of IGCAR and other DAE Units at Kalpakkam on safety and security related issues. They visited FBTR, MAPS and BHAVINI.

Shri T.K.Rangarajan, Hon'ble Member of Parliament in consultation with Dr. Baldev Raj, Director, IGCAR

Shri T.K.Rangarajan, *Hon'ble Member of Parliament* visited the Centre on August 12, 2008 and held discussions with Dr.Baldev Raj, Director, IGCAR. He visited FBTR, facilities in Post-Irradiation Examination Division, Non-Destructive Evaluation Division and Fast Reactor Technology Group and the project site of BHAVINI.

Prof.S.P.Thyagarajan and doctors from Sri Ramachandra Medical College and Research Institute, Chennai exchanging views with Dr.Baldev Raj, Director, IGCAR and other senior colleagues of the Centre

A team of doctors from Shri Ramachandra Medical College and Research Institute, Chennai led by Prof. S.P. Thyagarajan, Director, R&D visited IGCAR on August 14, 2008 to hold discussions with Dr. Baldev Raj, Director, IGCAR and other senior colleagues of the Centre. Proposals for mutual collaboration to work in the areas of health management and diagnosis were discussed. The team also visited Radiation Safety Division in Safety Group, Quality Assurance Division in Engineering Services Group and Materials Science Division in Metallurgy and Materials Group.

French Delegation led by Mr.Y.Kalunzy, Senior Vice-President, International Relations and Cooperation, Nuclear Energy Division, CEA, France with Dr.Baldev Raj,Director, IGCAR and other senior colleagues of the Centre

A **French delegation led by Mr.Y.Kalunzy,** *Senior Vice-President, International Relations and Cooperation, Nuclear Energy Division, CEA, France* visited the Centre to participate in the CEA-DAE mid year review meeting held at IGCAR on September 11, 2008. Dr. Baldev Raj, Director, IGCAR gave a perspective on the collaborative programmes. There were presentations by senior colleagues on design and safety aspects of Fast Reactors and by the members from the visiting CEA team. Discussions on the status of the collaborative projects and identification of new areas where future bilateral participation could be made followed the presentations. The team visited FBTR, Hot Cells, facilities in Fast Reactor Technology Group, Sensor Laboratory in Chemistry Group and BHAVINI.

Other Visits Shri S.C.Sharma, *Consultant Power and Energy Division, Planning Commission*, New Delhi visited IGCAR, MAPS and BHAVINI on August 27, 2008. At IGCAR he visited FBTR, Hot Cells, facilities in Fast Reactor Technology Group, Structural Mechanics Laboratory and Laboratories in the Safety Group.

Forthcoming Meetings / Conferences

25th DAE Safety & Occupational Health Professionals Meet

December 18 – 20, 2008

The annual DAE Safety & Occupational Health Professionals Meet (started in 1983) is conducted at Kalpakkam. The 25th meet will be jointly hosted by AERB and DAE Units at Kalpakkam. The Ministry of Labour and Employment, Government of India has declared year 2008 as the Year of Industrial Safety & Health. The Theme of the meet is Safety Management, Safety Culture & Industrial Medicine.

Theme of the Meeting

Safety Management, Safety Culture & Industrial Medicine

For more information, Please contact :

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Venue: Convention Centre, Anupuram

- **Dr. Baldev Raj** has been invited by 'Global Energy' to be a member of the "Global Energy International Prize Committee for 2009-2013" for selecting the awardees for research and development in the area of energy in the world along with other members which include Nobel prize winners in the field of Physics and Chemistry.

  He has been made as Member, Nanotechnology Advisory Board, Department of Science & Technology, Government of South Africa.

  He has also delivered twenty fourth Prof. Brahm Prakash Memorial Lecture organized by Indian Institute of Metals, Bangalore Chapter on August 21, 2008.

- **Dr. P.R. Vasudeva Rao,** Director, Chemistry, Metallurgy & Materials Groups has been awarded Indian Nuclear Society Award : Nuclear Fuel Cycle Technologies, including Radiation Safety and Environmental Protection for the year 2007 by Indian Nuclear Society.

- **Dr. C.S. Sundar,** Head, Material Science Division, MMG has been awarded "Tamilnadu Scientist Award (TANSA) 2007" under the discipline Physical Sciences by Tamilnadu State council for Science and Technology.

- **Dr. John Philip,** Non Destructive Evaluation Division, MMG has been awarded Indian Nuclear Society Medal for the year 2007.

- **Shri. G. Padmakumar,** Separation Technology & Hydraulics Division, FRTG has been awarded with Indian Nuclear Society Medal for the year 2007.

- **Shri Sumantra Mandal,** Materials Technology Division, MMG has been chosen as the recipient of the "2009 SHRI RAM ARORA AWARD" for Materials Science and Engineering Education from The Minerals, Metals and Materials Society (TMS), USA.

- "HOMI BHABHA Quality Circle", Planning Section, Central Workshop Division led by Shri G. Kempulraj with members Shri T. Saravanan, Shri K. Narayanan, Shri Kumaran, Shri Chandrasekharan and Shri P. Shanmugam has won the "PAR EXCELLENCE" award, the highest in quality circle competitions at Quality Circle Convention (CCQCC-2008).

- "SAMURAI Quality Circle", Maintenance & Inspection Section, Central Workshop Division led by Shri V. Praveen Kumar with members Shri C. Palani, Shri N. Chockalingam, Shri A. Magendran, Shri P.M. Ajithkumar and Shri Ramalingam got "'Distinguished award" during circle competitions at Quality Circle Convention (CCQCC-2008).

IGCAR pays Homage to Prof. C.V. Sundaram

Prof. C. V. Sundaram, Distinguished Metallurgist and former Director of the IGCAR passed away in the early hours of **August 15, 2008**. He is fondly remembered by his family members, peers, collaborators and a large number of his younger colleagues whom he mentored, in his lifetime.

Prof. C. V. Sundaram was born on **November 7, 1929** in Ottappalam, Kerala. He had his early training in chemistry and metallurgy. He commenced his research work in chemical metallurgy under the supervision of Prof. Brahma Prakash, at Indian Institute of Science, Bangalore in 1952. He joined Department of Atomic Energy in 1956. Prof. C.V. Sundaram was a major architect in ushering an era of production of rare, reactive and refractory metals, such as zirconium, beryllium, titanium and tantalum, utilising indigenous resources and expertise. His research contributions led to the establishment of a production plant for nuclear grade materials such as zirconium sponge, niobium and tantalum metal products at Nuclear Fuel Complex, Hyderabad. In 1982, he was invited to assume leadership of the Fast Breeder Reactor Programme of India as the Director of IGCAR at Kalpakkam, at a crucial stage when the construction of the Fast Breeder Test Reactor was nearing completion. Through his dedication, hard work and inspiring leadership, he led the team of scientists and engineers in IGCAR towards the successful criticality of FBTR in October 1985. The glorious success of the FBTR program today owes a lot to the leadership and guidance of Prof. Sundaram in the crucial years. Prof. Sundaram was also closely associated with the development of the Prototype Fast Breeder Reactor (500 MW(e)), currently under construction at Kalpakkam. R & D work programme was defined during his tenure as Director of IGCAR. Subsequent to his retirement from DAE in 1989, he served as a consultant to the Nuclear Fuel Complex, and was subsequently a Homi Bhabha Visiting Professor and then a Honorary Visiting Professor at the National Institute of Advanced Studies at Bangalore till July 2001.

Prof. Sundaram was a recipient of several prestigious awards including the National Metallurgists' Day award (1970), Platinum Jubilee Alumnus Award of Indian Institute of Science (1985), INS Homi Bhabha Life Time Achievement Award of Indian Nuclear Society (2001) and Life Time Achievement Award from Ministry of Steel and Mines, Government of India (2006). He was elected 'Fellow' of the Indian National Science Academy, Indian National Academy of Engineering and Indian Academy of Sciences. He served with distinction as the Chief Editor of the Transactions of the Indian Institute of Metals and President of the Indian Institute of Metals and President of the Indian Nuclear Society. For his outstanding scientific and technological achievements, Government of India honoured Prof. C.V. Sundaram with the Sanjay Gandhi Award for Science and Technology in the field of energy (1985) and Padma Bhushan Award (1986).

Prof. C.V. Sundaram pursued his career as an opportunity to serve science and fulfill himself. He was inspired by the thoughts of several leaders such as Swami Vivekananda and Mahatma Gandhi. He was a humble and compassionate human being and an articulate speaker and writer. He was always keen to foster talent and develop new leaders for the future. He had his entire education, training and a major portion of his research in India. He had genuine pride in things that are Indian and was very keen to promote frontiers in science and technology in India. In his passing away, India has lost one of her worthy sons, who was a true leader in science and technology and more important a par excellent human being.

IGCAR pays Homage to Dr. Placid Rodriguez

Dr. Placid Rodriguez, Distinguished Metallurgist and former Director of the IGCAR passed away on **August 31, 2008** at Chennai.Dr. Placid Rodriguez was born in Quilon, Kerala on **October 5, 1940**. He obtained B.Sc from Kerala University, B.E (Metallurgy) from the Indian Institute of Science (IISc), Bangalore, M.S from University of Tennessee, USA and Ph.D from IISc and MBA from Indira Gandhi National Open University. He joined the Department of Atomic Energy in 1960 and worked in Bhabha Atomic Research Centre, Bombay till 1974. In 1974, he has moved to Indira Gandhi Centre for Atomic Research, Kalpakkam (then Reactor Research Centre) as a senior metallurgist and established world class research laboratories for metallurgical research. He was the Director of IGCAR, Kalpakkam from December 1992 till October 2000. Dr. Rodriguez is internationally well-known for his R&D contributions in Mechanical Metallurgy, Welding Metallurgy and Nuclear Materials. He has guided and nurtured several young colleagues in the multidisciplinary fields of Science and Engineering for the advancement of fast breeder reactor technology in India.

He served as Chairman of Recruitment and Assessment Centre of Defence Research and Development Organisation in New Delhi from Nov. 2000 to October 2003. Since 2004, he has been Raja Ramanna Fellow at IIT Madras, Chennai and AICTE-INAE Distinguished Visiting Professor at NITs at Surathkal, Nagpur, Tiruchirapalli & PSG College of Technology, Coimbatore.

He served with distinction as a member of Editorial Board of several reputed international journals in Metallurgy and Materials Science and was the Chief Editor of Transactions of The Indian Institute of Metals during 1987-1997.

Dr. Rodriguez has been a recipient of many National and International awards. Notable among them are National Metallurgists' Day Award of the Ministry of Steel and Mines, G.D. Birla Gold Medal of the Indian Institute of Metals, VASVIK Research Award for Materials Science and Technology, Platinum Medal of the Indian Institute of Metals, Life Time Achievement Awards of The Indian Institute of Welding and Indian Nuclear Society. He has been Fellow of the Indian National Academy of Engineering, The Indian Academy of Sciences, The National Academy of Sciences India and The Indian Institute of Metals.

Dr. Rodriguez, has played important leadership roles in the Professional Societies. He served as President of The Indian Institute of Metals, The Indian Institute of Welding and Indian Nuclear Society. He served as Honorary Secretary as well as the Vice –President of the Indian National Academy of Engineering

Dr. Rodriguez has been a member of many national funding agencies for Science and Technology like Science and Engineering Research Council of Department of Science and Technology, Board of Research in Nuclear Sciences, and chaired the TIFAC Committee on S&T inputs to small and medium enterprises. Dr. Rodriguez served as a member of the Scientific Advisory Committee to the Cabinet.

He is survived by wife and two children.

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