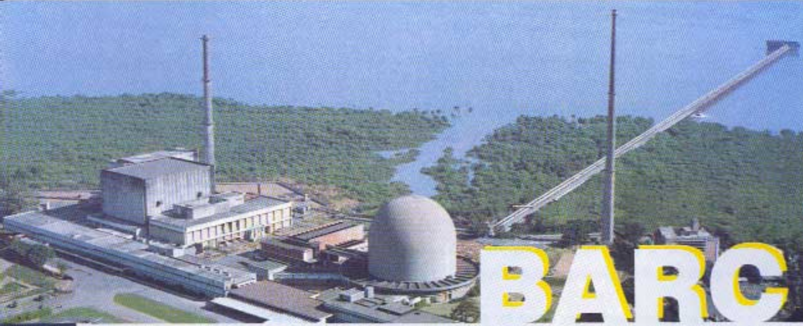

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FISSION SIGNATURES OF TESTS ON SUB-KILOTON DEVICES

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Introduction

Five Nuclear Tests conducted during May 11-13, 1998 at Pokhran, Rajasthan, included three sub-kiloton devices in addition to a thermonuclear device and a standard fission device. One sub-kiloton device was tested on May 11, while on May 13, two sub-kiloton devices were tested. This report gives some of the results of gamma radiation logging measurements in bore holes at the sites of sub-kiloton tests as well as the post-shot radioactivity measurements on the samples extracted from these sites.

Gamma Radiation Logging

Gamma radiation logging was carried out in the bore holes drilled at each of the test sites. The equipment used for this purpose was developed in Radiation Safety Systems Division, BARC. The equipment consisted of a measuring unit and detector probe unit coupled by long cable wound on a cable winch. The main detector probe consisted of two energy compensated GM tubes to cover six decades of range from 2 μGy/hr to 200 mGy/hr Full Scale Division (FSD). Necessary preamplifier for driving the signal through the long cable was provided inside the probe

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unit itself. The measuring unit incorporates necessary high voltage supply for detectors, count rate meter, scaling circuits and an audio circuit. All the readings were displayed by linear 50 division meter. The audio facility was quite useful to monitor the health of the instrument during logging. Before and after each logging, the instrument was checked with a test source. The instrument was initially calibrated at BARC for all the ranges at different points in each range using various source strengths.

These measurements have shown the presence of gamma emitters at all the test sites. Figure 1 gives the variation of gamma dose along depth for 0.5 kt device test site.

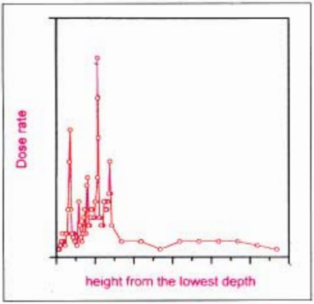

Fig. 1 Gamma dose rate at the test site of 0.5 kiloton device of May 13, 1998

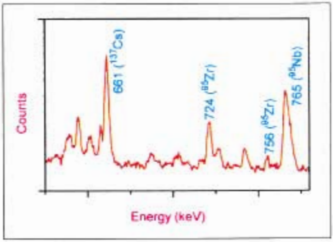

Fig. 2 Gamma spectrum of a typical sample from the test site of 0.3 kT device

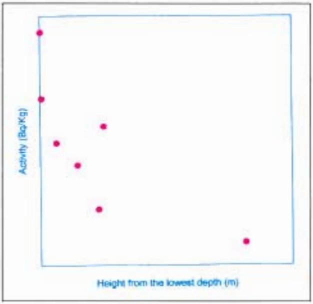

Fig. 3 Variation of ^{137}Cs activity with depth for 0.2 kt device

Identification of Radioactive Species

The samples extracted from boreholes at all test sites were assayed for radioactivity content at Environmental Assessment Division. Samples were powdered and dried. The homogenised samples were stored in plastic containers of 8 cm height and 7 cm diameter. For the assessment of radionuclides, two high resolution gamma-ray detectors, having efficiency of 20% and 30% respectively with respect to a 7.5 cm X 7.5 cm NaI(Tl) detector coupled with 8K Gamma Spectrometer, were used. Standard ^{152}Eu sources were used for efficiency calibration of the detectors in the specified geometry. Figure 2 gives a typical gamma spectrum of a sample collected from 0.3 kt device test site. The spectra clearly shows the presence of fission products such as ^{137}Cs, ^{95}Zr and ^{95}Nb. Data on large number of such samples drawn from various depths have been recorded for further analysis. Figure 3 shows the variation of ^{137}Cs activity with height from the lowest point for 0.2 kt device test site.

Acknowledgements

The authors would like to express their thanks to colleagues from Atomic Minerals Directorate for Exploration & Research, Repository Projects Section, BARC, the Army and team of health physicists who carried out the drilling operation and collection of samples.

The authors acknowledge with thanks the useful discussions with Dr. S.K. Sikka and Dr. B.S. Tomar. We express our gratitude to Dr. R. Chidambaram for his keen interest and encouragement during this work.

BARC DEVELOPS ON-LINE FATIGUE-CREEP MONITORING SYSTEM

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Introduction

Thermal and nuclear power plants are highly capital intensive and hence it is necessary to ensure not only their safe operation, but also their economic viability in the long run. Integrity of important components is essential for operational safety, reliability and low cost operation. Normally, a power plant is designed with a life expectancy of 30 to 40 years to produce continuous power economically. However, because of conservatism in the design, the actual lives of these plants are expected to be much more than the estimated value. The sustained interest in the area of remaining life prediction arises from the need to avoid costly outages and to ensure safe operations, and the necessity to extend the component operation life beyond the original design life. In power generation systems, many structural components, such as steam pipes, superheater headers, and turbine rotors operate at elevated temperatures. At the same time, they are also subjected to cyclic loading due to fluctuation of process parameters. Hence, these components are exposed to a damage mechanism caused by fatigue, creep and creep-fatigue interaction. Thus, there is a need for the development of a life prediction methodology which can account for this combined damage mechanism.

Utility Benefits

The benefits of such fatigue-creep monitoring system (FCMS) are as follows:

(i) Generating data base for the designers about the actual plant transients.

(ii) Guiding plant operators to adjust operating procedures and in-service inspection programs based on actual damage.

(iii) Assessing the structural integrity of the pressure boundaries after an event in which operating pressure and temperature exceed the limits.

(iv) Recording of material degradation due to fatigue, creep and fatigue-creep interaction.

(v) Supporting in life estimation and life extension programs of plants.

Plant Locations Susceptible to Fatigue-Creep Damage

It is neither possible nor necessary to monitor the degradation effects for all the components of a plant. An in-depth understanding of the possible damage mechanism and the plant process dynamics is essential for the selection of an optimum number of components. Some typical components of nuclear and thermal power plants which require damage monitoring, are detailed below.

In boiling water reactor (BWR), pressurised water reactor (PWR) and pressurised heavy water reactor (PHWR) type nuclear power plants, fatigue is the most important aging effect which causes failure. Here creep is not very important as operating temperature is not very high. For PWR, the components generally selected are charging nozzles, surge lines, steam generator feed water nozzles, safety injection nozzles, etc. Feed water nozzles, CRD return nozzles, etc. are selected for BWR plants for fatigue monitoring. In the case of PHWR, end fitting, pressuriser, steam generator tube sheet, etc. are the components which will be most severely affected due to the plant transients. In fast breeder reactor, the temperature is much higher and creep plays a vital role in failure mechanism.

In thermal power plants, the combination of thermal and pressure cycles cause creep and fatigue damage, particularly in heavy section components such as boiler headers, steamlines, turbine casings, superheater and reheater tubes, nozzle blocks and valves. The accumulated creep-fatigue damage causes the component to crack, leak and in some cases fail in a catastrophic manner. Secondary superheater outlet headers are particularly prone to ligament cracking as a result of creep-fatigue interaction. By monitoring the temperatures and the difference in temperature at the tube legs and header body, the degree of damage can be assessed and possibly controlled if the differences can be minimised through operational changes. Economiser inlet headers are also known to crack in the ligament area as a result of thermal shock. During shutdown of the boiler, the drum level drops and slugs of cold water are fed into the system via the inlet header. The frequent changes of temperature lead to fatigue damage. Turbine casings and blades usually crack due to thermal fatigue. The combination of thick walls, rapid transients due to blade grooves and changes in section size promote the susceptibility of crack initiation. The steamlines are subjected to thermal and pressure transients as well as changes in global stresses due to hanger/ support system. These components require a system to monitor the effects of creep, fatigue, creep-fatigue interaction and crack growth due to fatigue and creep. In chemical process industries, fatigue or both creep and fatigue based on the operating temperature of the plant are the crucial damage factors which cause structural degradation or failure of the component.

BARC Fatigue-Creep Monitoring System

In BARC, a fatigue-creep monitoring system (FCMS) has been developed. The system converts the plant transients to temperature/ stress responses using finite element method (FEM) and transfer function approach. This computes the fatigue usage factor using rainflow cycle counting algorithm. The creep damage index is evaluated from the computed temperature and stress histories and the material creep curve. The damage accumulation approach is adopted to account for the combined damage mechanism.

The code is capable of handling fluctuating pressure, thermal load and piping loads. From the recorded process transients (temperature and flow rate), the temperature responses at the selected component are computed using a transient thermal finite element analysis. The thermal stresses are calculated from the temperature field. The stresses due to internal pressure and piping loads are evaluated using a stress data base which is again generated using finite element method. The stresses due to thermal load, internal pressure and piping loads are superimposed. The fatigue, creep and creep-fatigue interaction effects are estimated at several nodal points of the structure. The code is written in C language. Some special features of the various modules of this system are listed below.

Temperature Transient Module

- The formation of element coefficient matrices is done every time to avoid their storage.
- The solution of transient equations is obtained by using Galerkin's method.
- The active column solver is used to solve the set of equations.
- The temperatures and the thermal load vector at the end of previous day's calculations is stored in a restart file for the computation to proceed for the next day.

Stress/Deformation Module

- The decomposed assembled stiffness matrix, after forward elimination, is stored as a data base to be used at the beginning of every day's processing.
- For the subsequent solutions, only back substitution is required for a new load vector corresponding to every record.
- The solution scheme is again the active column solver.

Integration of System Induced Loads

Structural degradation may be attributed to parameters such as variation in the internal pressure, temperature and flow. Generally, such monitoring systems take care of fluctuations in the process parameters. Apart from these process parameters, the additional system induced external loads may also contribute to degradation of components. These external loads usually arise from the piping system. The external loads and bending moments acting on the selected component are computed by carrying out the flexibility analysis of the piping system. The resultant stresses are computed using a 3-D finite element analysis. Through this analysis, a data base is generated for the selected components for unit change of process temperature and pressure. This data base is used in the present system and these stresses are superimposed with the stresses due to process parameter fluctuations.

Fatigue, Creep and Creep-Fatigue Interaction Module

The recorded plant transients are converted to structural stress and temperature responses using finite element method. In the present system, elastic stress analysis is performed. Effects of inelasticity is not considered. As per the ASME Boiler and Pressure Vessel (Section III, Code Case N-47) guidelines for calculation of fatigue and creep damage, elastic stress analysis is acceptable. The cycles are counted based on the rainflow cycle counting algorithm and the fatigue usage factor is evaluated from the material fatigue curve. The creep damage index is evaluated from the computed elastic stress intensity and the material creep curve (ASME Boiler and Pressure Vessel Code). The combined creep-fatigue interaction is computed using combined damage mechanism rule.

Screening of Transients and Data Storing

The plant transients are generally recorded by a data recording system at a particular time interval. This time interval may be as small as, for example, 0.1 sec., or as large as 5 sec. This depends on the nature of the plant transients and the recording system. In some particular situations, when the transients are insignificant, the processing of these records are not necessary. In the present system, there is a provision of screening the input data recorded from the plant instrumentation. This helps in reducing the number of records to be processed. The transients are screened based on the severity of the fluctuations and only relevant records are further processed.

In the present system, the whole field information for temperature, stresses and fatigue usage factor are stored. The damage index is updated after the computation of each day and stored as a record. The time history variations of recorded process flow, computed structural temperature, stresses and damage parameters are also stored. The variations of structural responses (e.g., structural temperature, stresses, etc.) are stored at few selected points on the structure.

Graphics Display Module

A user friendly graphics module is incorporated for display of relevant results. When initiated, this module displays the components selected for fatigue monitoring at the plant site. For a particular component, this shows the geometry, the material properties used and the finite element mesh adopted. The recorded fluid transients are displayed giving quantitative information of the operating conditions of the plant. The computed stress and temperature histories are also available for display. The calculated rainflow cycles are plotted as a stress frequency spectrum. The fatigue usage factor, creep damage index and the combined fatigue-creep damage index histories can be seen on screen or plotted on the paper. The whole field information for structural temperature, stresses and damage index are also displayed.

Data Compression Algorithm and Safety Features

The number of records of temperature and stress histories are accumulated as the system runs for a long period. A data compression algorithm has been incorporated to restrict the number of history records. The principle of rainflow cycle counting method is adapted in this compression algorithm. Once the number of records exceeds the specified storage capacity, the smaller stress or temperature excursions are eliminated from the data base.

The system has built-in safety features against some unforeseen conditions caused by power failure or human error while the computation is on. These features protect the system from malfunctioning under these situations. A backup directory is created and all the files are stored in the backup directory. When the system is installed, all the relevant files from the backup directory are copied to the working directory. After each day of computation, the results are checked, and if all the computations are performed satisfactorily, the updated results are copied to the backup directory. In case of an erroneous computation (due to some error in input signals, etc.), power failure or arbitrary interruptions to the system, the files from the backup directory would be recopied to the working directory. The operation of the system would not be affected although the data for that particular day would be lost.

Fig. 1 BARC on-line fatigue monitoring system implemented at Heavy Water Plant, Kota

Implementation and Experience of FCMS

The FCMS was installed at Heavy Water Plant (HWP), Kota, in mid 1996 (Fig.1). In HWP Kota, the process temperature is much below the temperature range of creep; hence the creep module is not actuated. Three nozzles are selected for fatigue monitoring: gas outlet nozzle connected to the spherical head of the waste stripper column (N01), gas inlet nozzle connected to the cylindrical column tower (N02), and inlet recirculation nozzle to the column tower (N13). The system is combined with a disturbance recording system (DRS) developed by Reactor Control Division. The DRS continuously acquires process parameters associated with the selected components. Every night at zero hours, the fatigue monitoring module is triggered. The recorded process data are screened and only significant transients are selected for further computation. Typical process transients recorded after screening the insignificant fluctuations for the gas inlet to column tower (N02) are shown in Fig.2.

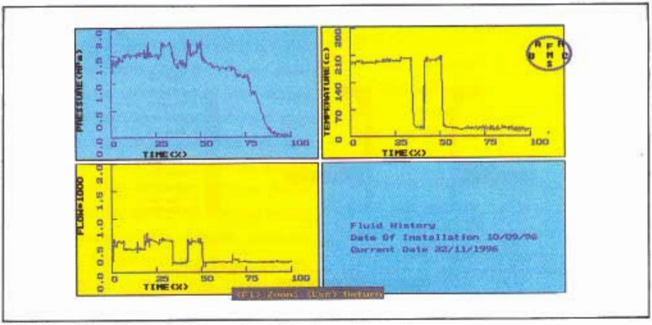

Fig. 2 Recorded process pressure, temperature and flow for gas inlet to column tower

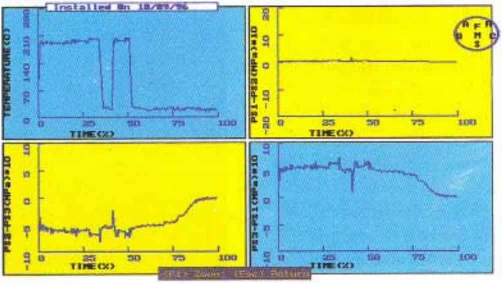

Fig. 3 Computed temperature and stresses at a critical point of gas inlet to column tower

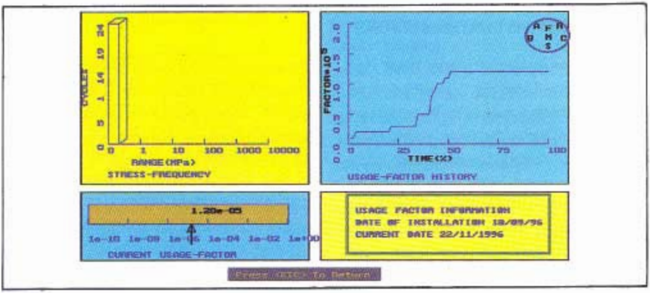

Fig. 4 Computed rainflow cycles and usage factor at a critical point of gas inlet to column tower

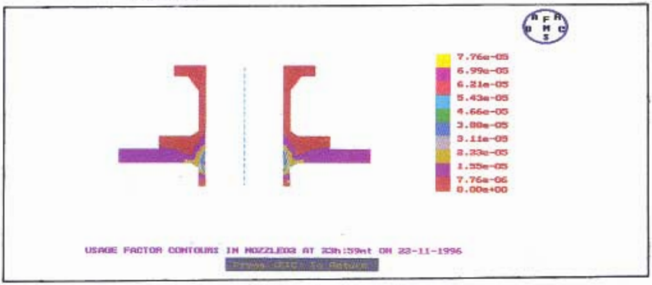

Fig. 5 Computed fatigue usage factor contour of gas inlet to column tower

Figure 2 shows the recorded process transients in this plant over a period of time. The variation of the computed temperature and stresses at a selected point of this nozzle is shown in Fig.3. The fatigue usage information of the same point is shown in Fig.4. In this figure, the calculated stress frequency spectrum from stress histories is shown in the form of a bar chart. The final fatigue usage factor is displayed on a logarithmic scale. The fatigue usage factor history is also displayed in Fig.4. The usage factor contour of the gas inlet to column tower is shown in Fig.5. The computation is repeated for all the nozzles in sequence.

A similar system will be implemented at HWP, Tuticorin. In HWP Tuticorin also, three components are selected for fatigue monitoring. These components are shell nozzle junctions connected with the ammonia drier. The necessary finite element based data base, software and hardware are ready for installation.

Discussion

The present fatigue-creep monitoring system is a dedicated software for on-line monitoring of fatigue, creep and creep-fatigue interaction of components in a plant. The system can be easily integrated with a data recording system to access plant data. This can convert plant transients to temperature/ stress responses of the structure using finite element method. The fatigue usage factor is calculated using rainflow cycle counting algorithm. The creep and creep-fatigue interaction is accounted as per the guidelines of ASME Boiler and Pressure Vessel Code. A user friendly menu driven display of various information related to plant transients, computed stress and temperature responses, damage parameter, etc., is another feature of the present system. The computation is fast enough to monitor the damage of several components of a plant using a single personal computer. The present system will be very useful in life estimation and life extension program of components of a plant.

The experience of the installation and performance of the system at HWP Kota is significant. The creep and the creep-fatigue interaction modules will be of significance in the case of thermal power plants, fast breeder nuclear power plants and chemical process industries.

Availability at Web Site

Recently, a worldwide technical information network FAMONET (FAtigue MOnitoring system NETwork) has been established. The aim of this network is to set-up a framework to facilitate the exchange of information between research organisations and industries dealing with the development of fatigue monitoring systems for integrity assessment and maintenance of power plant components. Within this network, the various organisations developing fatigue monitoring systems are able to exchange technical information on the existing systems and their experience feedback, make benchmarking exercises and use the same sets of data to auto-check their systems and enhance their quality. The members of this network are BARC, India; Electricite de France (EDF) and Framatome, France; Structural Integrity Associates (SI) and Westinghouse, USA; GKN, AMTEC and MPA Stuttgart, Germany; Tractebel, Belgium; Tokyo Electric Power Corporation, Mitsubishi and Toshiba, Japan; etc. A world wide web site has been created for this purpose. The related technical information of BARC Fatigue-Creep Monitoring System is available at http://www.structint.com/famonet/.

INDIA'S ACHIEVEMENTS AND IAEA'S ROLE IN THE DEVELOPMENT OF NUCLEAR ENERGY FOR PEACEFUL PURPOSES

(In his statement presented at the 43rd General Conference of the International Atomic Energy Agency (IAEA), Vienna, during September 27-October 1, 1999, Dr R. Chidambaram, Chairman, Atomic Energy Commission, reminded the IAEA to promote the development of atomic energy as a harbinger of peace, health and prosperity throughout the world, instead of functioning as a mere police body which is concerned only about safety and safeguards - a view expressed by Dr Homi Bhabha in 1956 at the Conference on the Statute of the IAEA.

Following are the extracts from Dr Chidambaram's statement which not only outlined India's achievements in the peaceful applications of nuclear energy including power generation, but also provided guidelines for the IAEA in its future role as a promoter of research and development programmes for harnessing spin-off technologies, and for facilitating the peaceful uses of weapons-surplus nuclear material as fuel for nuclear power reactors.)

"Among these peaceful applications of nuclear energy, and from the standpoint of developing countries and looking at their possible access today and in the future to fossil fuel resources of the world, nuclear power generation is the foremost. While the decision to pursue the nuclear power option is no doubt a national one, the Agency's mandate to promote in an objective manner the contribution of atomic energy to peace, health and prosperity should not be eroded while it discharges its responsibilities of helping to ensure safety and implementing safeguards. Increasingly, the Secretariat has become diffident on nuclear power related matters, perhaps influenced by the environment in which it is located, where power generation, having reached a point of saturation, finds it difficult to find support for new nuclear plants. However, while nuclear power may be stagnating in Europe and North America, it is growing fast in Asia and some other parts of the world where it is being looked upon as an inevitable option to satisfy future energy needs."

"One quantifiable measure of economic development of a country is the per capita consumption of electricity. For Indians to reach a standard of living which will be somewhat comparable to those living in developed countries, it has been estimated that the per capita consumption of electricity should increase at least by a factor of 8 to 10. Internal reviews have led us to conclude that, in the coming century, nuclear energy will account for an increasing share of the electricity mix in India. It is our endeavour to reach 20,000 MW(e) of nuclear power by the year 2020 as a first step. In the last one year, our efforts to accelerate our nuclear power programme to reach that target have borne fruit. The performance of our ten nuclear power plants in the last three years has been improving consistently. In 1998-99 the overall capacity utilisation was 75%. For the period from April to August 1999, the capacity utilisation touched a high of 78%."

"To ensure long term energy security, India has chosen to follow a 'closed-fuel cycle' policy which calls for the setting up of reprocessing plants and breeder reactors. Our Fast Breeder Test Reactor at Kalpakkam, over a decade old, has achieved all technological objectives. The indigenously developed, and hitherto untried, mixed Uranium-Plutonium carbide fuel has reached a burn-up level of 49,000 MWd/t (upto July 1999) and has performed excellently as revealed by post-irradiation examination. A programme of irradiation of zirconium-niobium capsules for irradiation creep measurements was carried out. With the rich experience gained from the FBTR operation, the indigenous design and development of the 500 MWe Prototype Fast Breeder Reactor (PFBR) is progressing well and the construction is expected to begin in 2001. The preliminary Safety Analysis Report on Reactor Assembly, Heat Transport System and Component Handling have been completed. A four legged walking robot for in-service inspection of the PFBR steam generator has been designed and developed."

"Mature technologies for reprocessing, waste management and recycle of plutonium have been demonstrated and are available. Progress is under way on the Thorium-Uranium 233 cycle also. In this context, it is worth mentioning that because of our great interest in the closed nuclear fuel cycle, we have always considered spent fuel as a vital resource material..... The closed fuel cycle, adopting a 'reprocess to recycle Pu' approach after extended period of spent fuel storage, has several advantages. It renders reprocessing and nuclear waste management a more viable and safe technology, with reduced Man-Rem expenditures, since it minimises the complication due to the presence of Americium-241 in the recycled fuel fabrication process. The planning of reprocessing capacity should be such that the needs of the fast reactors/advanced PHWR, etc. which facilitate the utilisation of Plutonium and Thorium, while reducing the input of natural Uranium (in the process realising the much higher energy potential of Uranium), can be met on 'Just in Time' basis, which is a very important concept in materials management. Americium is not of any proliferation concern and this has also been borne out by the Board's recent decision in this regard."

"An Advanced Heavy Water Reactor (AHWR) using plutonium and Uranium^{233} as fuel is being designed at BARC. AHWRs constitute a part of the third stage of our nuclear power programme which will mark a transition to thorium based systems as it will use as fuel the U^{233} obtained by the irradiation of thorium in PHWRs and FBRs. Our 30 kWt experimental reactor, KAMINI, at Kalpakkam using indigenously fabricated U^{233} based fuel has attained its full power. The facility is being used for neutron radiography and also for various experiments related to neutron analysis."

"The power programme has a support base ranging from fuel fabrication to electronics and heavy water facilities. Based on design and development at BARC, the Electronics Corporation of India Limited (ECIL) has produced the Supervisory Control & Data Acquisition (SCADA) system for switchyard and power equipment for the new power stations in Rajasthan. This is a sophisticated system which provides for the monitoring from the main control room of the status of various power equipment in the nuclear power station and permits the operation of circuit breakers and isolators in the switchyard. The Nuclear Fuel Complex (NFC) developed a novel method for production of seamless zircaloy-4 square channels for the two Boiling Water Reactors (BWR) at Tarapur which were hitherto imported. The zircaloy-4 square channels are manufactured from seamless tubes employing a square die and a draw bench."

"Since its inception, our nuclear programme has been characterised by a holistic approach. Thus, while power generation is indeed a matter of priority, non-power applications of nuclear energy in areas such as medicine, agriculture and industry are given equal emphasis in our R&D programme. The Isomed Plant, the facility in Trombay for sterilisation of medical products operated by the Board for Radiation & Isotope Technology (BRIT), has completed 25 years of successful operation and has been providing sterilisation service to medical industries in and around Mumbai."

"With a population of nearly a billion, food security is a crucial issue for us. Radioisotopes are being used to improve fertilizer use efficiency, monitoring the fate and persistence of pesticides in soil, ground water and environment, reduction of post-harvest losses by extension of shelf life and preventing damage from insect and microbial contamination. Research efforts at BARC have resulted in 22 mutant varieties for commercial cultivation. Radiation processing of a wide variety of food items have been undertaken since 1994. A commercial facility for radiation processing of spices is nearing completion at Navi Mumbai."

"The Radiation Medicine Centre which pioneered nuclear medicine in India is involved in R&D in health science using radionuclides. Recently, we have tied up with a Veterinary College in Mumbai to extend nuclear medicine facilities to small animals such as dogs, cats and goats. Subsequently, this facility will be extended to large animals. During the year, the Tata Memorial Hospital (TMH) Tissue Bank contributed to the development of the 'Multi-media Distance Learning Package on Tissue Banking' produced under the Regional Cooperative Agreement (RCA) for Asia and the Pacific under the auspices of the IAEA. In fact, a wide range of R&D activities fall under the RCA including research reactor utilisation, radiation protection, tracer technology and electron beam applications."

"At the Tata Institute of Fundamental Research (TIFR), a LINAC booster for the existing Pelletron Accelerator has been developed. The cryogenic aspects of the design and fabrication has resulted in a spin-off for the cryogenic industry in the country with many engineering problems being solved for the first time. A 450 MeV Synchrotron Radiation Source (SRS) Indus-1 became operational at the Centre for Advanced Technology (CAT), Indore, in April 1999. ...... The first indigenously built tokamak ADITYA has been operational since 1989 and has led to significant discoveries on intermittency and bursty transport due to coherent structures in tokamak edge turbulence. Our second generation experiment - a steady state superconducting tokamak, SSTI - is currently under fabrication and is likely to be the first such experiment in the world to generate 1000 second plasma pulses."

"..... It is important to realise that fusion plasma research not only prepares one technologically to reap the benefits of fusion power when available, but also leads to the development of spin-off technologies in the areas of large volume UHV systems, cryotechnologies, large copper and superconducting magnets, AC and DC power systems, sophisticated data acquisition and control systems, lasers, microwave and spectroscopic diagnostic system, etc. The IAEA has played a crucial role in the context of the International Thermonuclear Experimental Reactor (ITER) programme. A similar platform could be provided to non-ITER countries to think of joint long term activities and to foster linkages with ITER."

"..... It would be appropriate to encourage activities to facilitate the peaceful uses of weapons surplus material as fuel for nuclear power reactors and also for harnessing spin-off technologies. Economic gains from such activities, which should be open for participation to all countries without discrimination, could be used to meet part of the costs."

"..... In 1956, at the Conference on the Statute of the IAEA at New York, Homi Bhabha, while recognising that the problem of safeguards is one of the most serious and complicated one facing the Agency, cautioned against the creation of a safeguards system which would be unrelated to the realities of the world we live in and which would reduce the Agency from being a positive creative force to a police body."

"Over the last more than half a century, several nations developed nuclear technology for power generation through multiple approaches. And some of the countries which took the lead in this endeavour, especially the USA, the UK and in Europe, have, as a result of saturation of their electricity generation, decelerated or halted technology development while some other countries, of which India is one, have proceeded at a steady pace in adding to nuclear power generation and are persisting with technology development programmes. Clearly, the most desirable direction for the future is to go forward in operationalising simpler, innovative technologies for lower cost and, at the same time, ever-safe nuclear power generating systems."

"The IAEA must appreciate its unique position as the only international organisation, not only in the UN family but also in a global sense, to bring about the widest possible participation in, and thereby access to benefits from, wholesome international cooperation. The IAEA owes this to its Member States."

WORKSHOP FOR WORKING JOURNALISTS

At the instance of the School of Journalism and Communication of the National Union of Journalists (India), New Delhi, the Department of Atomic Energy (DAE) organised a five-day workshop for working journalists during September 6-10, 1999 in Mumbai. Nine journalists representing English and Hindi print media from various parts of the country participated in the Workshop.

Dr Anil Kakodkar, Director, BARC, meeting the participants of the Journalists' Workshop, conducted by DAE during September 6-10, 1999

A panel of DAE officers delivered comprehensive lectures covering subjects such as nuclear power generation, design & development in research reactors, front end of nuclear fuel cycle and materials for nuclear industry, fast breeder reactor, applications of radioisotopes in medicine, agriculture and industry, safety and environmental aspects, waste management, etc. The topics were selected keeping in view the issues that are of interest to the journalists. Apart from these lectures, visits to connected facilities at BARC, Tarapur Atomic Power Station and the BRIT were organised to give a physical impression and a flavour of the research environment. Dr R. Chidambaram, Chairman, AEC, Dr Anil Kakodkar, Director, BARC, and Mr Y.S.R. Prasad, Chairman & Managing Director, NPC, discussed various aspects of the Nuclear Programmes of the Department in a more open-ended manner during their meeting with the participants of the Workshop in successive days.

This is the fourth Workshop in the last two years organised by the Department exclusively for the benefit of the working journalists. The experience gained in the earlier Workshops was of immense help in making this even better focussed towards the needs of the participants. The participants felt that the workshop enabled them to become aware of the issues that concern the public, and get a more comprehensive understanding of important issues like safety and waste management.

TRAINING UNDER THE IAEA FELLOWSHIP PROGRAMME

During the year 1998-99, the Bhabha Atomic Research Centre provided training to 13 Fellows (from 5 countries) sponsored by the International Atomic Energy Agency (IAEA). The following table gives country-wise names of the Fellows, the fields and durations of their training, and the Divisions in BARC where the Fellows were trained. After completion of their respective training, all the IAEA Fellows were presented with a Certificate by Mr A.K. Anand, Director, Technical Co-ordination & International Relations Group, BARC.

COUNTRY	NAME OF THE FELLOW	FIELD OF TRAINING	DIVISION	DURATION MONTHS
BANGLADESH	AKM Zakaria	Neutron Diffraction	CMPD	6
	Md. Abul Kalam Azad	Neutron Diffraction	CMPD	6
	FBA Maroof	Tracer Technology	ID	3
	Md. Ashraful Islam	Tracer Technology	ID	4
	Md.Moinul Islam	Environmental Radioactivity	EAD	1
	Nasreen Banu	Radiological Emergencies	RPAD/MD	1
MYANMAR	Tin Tin Hlaing	Radiation Protection	RPAD	2
ROMANIA	Florin Alexiu	Radioimmunoassay	RMC/BRIT	4
THAILAND	Wanlop Weeradet	Radionuclide Therapy	RMC	1
VIETNAM	Duong Quong Tan	Decontamination Tehniques	RSSD	2
	Nong Minh Dung	Environmental Protection	HPD	2
	Quang Chinh Truong	Dosimetry & Radiation Biology	HPD	2
	Than Van Lien	Radioactive Waste Management	WMD	2

FORTHCOMING SYMPOSIA

■ The Indian Physics Association is organising a three-day Seminar on "Physics in 20th Century and Emerging Trends for the New Millennium" (IPAS-99) during November 10-12, 1999 at Homi Bhabha Auditorium, Tata Institute of Fundamental Research, Colaba, Mumbai 400 005. The main purpose of organising the Seminar is to highlight the path-breaking events which have taken place in Physics during this century and to take note of the emerging trends in the field for the next millennium. The Seminar will consist of a series of invited talks to be delivered by eminent physicists and other experts in the country and will attempt to cover important topics in Physics, such as :

- Quantum Mechanics and Relativity Theory
- High Energy Physics, Cosmic Rays and Nuclear Physics
- Astrophysics and Astronomy
- Accelerators and their impact on Science & Technology
- Nuclear Energy : Present Status and Future Projections
- Semi-conductor Physics, Microelectronics and Electronics Revolution
- Quantum Electronics and Lasers
- Atomic and Molecular Physics
- Advances in Condensed Matter Physics & Material Sciences
- Superconductivity
- Physics of Surfaces and New Materials
- Physics in Biology and Medical Applications
- Information Technology

These topics will be covered in the following talks.

Speakers and Topics

1. V. Singh (TIFR)
   Foundations of Quantum Mechànics, Relativity & Contemporary Views
2. J.V. Narlikar (IUCAA)
   Cosmology - Past, Present and Future
3. R. Cowsik (IAA)
   Global Perspectives in Astronomy
4. S.M. Chitre (TIFR)
   Outstanding Problems in Astrophysics - Personal Perspecitves
5. R.K. Choudhury (BARC)
   Evolution of Nuclear Physics of Stable Nuclei and Journey into the Unstables
6. B.K. Jain (BARC)
   Emerging Scenario of Nuclear Physics in the Non- and Sub-nucleonic Domain
7. B.C. Sinha (VECC)
   The Micro- and the Macro- Cosmos
8. A. Gurtu (TIFR)
   Standard Model of Fundamental Particles & Interactions
9. Amitabh Raychoudhary (Calcutta University)
   Beyond Standard Model
10. B.S. Shastry (IISc)
    Superconductivity and Strongly Correlated Electron Systems
11. Arup Raychoudhury (NPL)
    Physics of Small Things
12. O.N. Srivastava (BHU)
    Forthcoming Exotic Materials
13. Vikram Kumar (SSPL)
    Trends in Semiconductor Devices for the Next Decade
14. G.S. Agarwal (PRL)
    Quantum Optics : Perspectives and Prospectives

15. D. Mathur (TIFR)
    New Developments in Atomic and Molecular Physics
16. Shiv Prasad (IIT, Mumbai)
    Milestones in Materials Research
17. R. Chidambaram (BARC/DAE)
    Architecture of Matter : Exploring Matter with Photons and Neutrons
18. D.D. Bhawalkar (CAT)
    Laser and their Applications
19. P.K. Kaw (IPR)
    Challenges of Plasma Science
20. U.R. Rao (DOS)
    Space Science and Satellite Technology
21. Amit Roy (NSC)
    Accelerators and their Impact on Science and Technology
22. Anil Kakodkar (BARC)
    R&D for Nuclear Power in the Coming Decades
23. R.D. Lele (Jaslok Hospital)
    Imaging Techniques and Accelerators in Medicine
24. S. Ramani (NCST)
    Communication and Information Technology

For further details, please contact : Dr C.L. Bhat, Convener, Organising Committee, Nuclear Research Laboratory - NRL/HARL, Bhabha Atomic Research Centre, Mumbai 400 085.
E-mail : clbhat@magnum.barc.ernet.in
Fax : (022) 550 51 51

■ The annual DAE Solid State Physics Symposium will be held this year at the Indira Gandhi Centre for Atomic Research, Kalpakkam, during December 20-24, 1999. The scientific deliberations at the Symposium will cover a wide spectrum of research activities in the field of condensed matter physics, while focussing on some of the recent developments through presentations of research papers and Ph.D. theses, and lectures by invited speakers.

(Contact : Dr B.K.Godwal, Fax : (022) 550 51 51; Email: ssps@magnum.barc.ernet.in

BARC SCIENTIST HONOURED

Dr G.P. Das of Technical Physics & Prototype Engineering Division, BARC, was invited to participate in the *India-Japan Workshop on Materials Design by Computer Simulation* held in August 1999 at Sendai, Japan. His lecture entitled "Electronic Structure, Phase Stability and Ordering Behavior in Binary Alloy" was adjudged as the best presentation in the Workshop and he was presented with a commendation certificate. Dr Das has been involved in first-principles electronic structure investigation of various ordered and disordered alloys, epitaxial interfaces and multilayers, and also nanostructured materials. In this Workshop, he reported some of the recent results on Ni-Mo alloy system obtained at BARC.

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