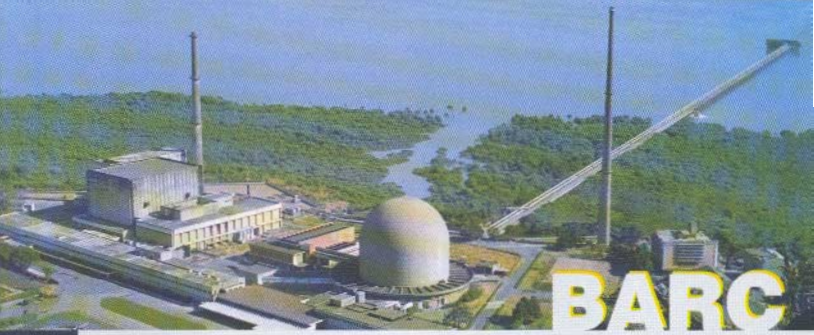

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ULTIMA 100+ : AN ULTRASONIC IMAGING SYSTEM FOR NON-DESTRUCTIVE TESTING OF MATERIALS

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Introduction

Ultrasonic Testing (UT) techniques for nondestructive examination of engineering components have evolved extensively over the last fifteen years. Ubiquitous Ultrasonic Flaw Detector faces a tough challenge from the modern computer controlled ultrasonic inspection systems that display cross-sectional images of test objects along with the familiar A-scan trace. Visualisation of defects in two dimensions is much more informative than mere defect indication and it also eliminates the subjectiveness of interpretation. This is precisely where the modern ultrasonic imaging systems score over the conventional flaw detectors. The primary advantage offered by such imaging systems is the possibility of a much superior quality control due to better defect sizing capability.

Over last ten years, Ultrasonic instrumentation Section, Electronics Division, has been concentrating on the design and development of advanced Ultrasonic Imaging Systems for inspection of materials. After a series of modifications, up-gradations and improvisations, the system suitable for several standard and application specific requirements has been developed and it has been designated as **ULTIMA 100+**. This article provides technical information regarding this system along with a brief description of some selected applications.

Contents

1. Ultima 100+ : an ultrasonic imaging system for non-destructive testing of materials 1
2. BARCIS 2000 system ready for handing over to NPCIL 7
3. Remote repairs to helium pipe flange joints inside cirus pile block 10
4. Inauguration of new analytical facilities of Chemical Engineering Division 10
5. A non-electrolytic route for the production of uranous nitrate solution as an input to Purex process 12
6. INAE-DAE seminar on 'Radiation processing of food products' 12
7. IAEA/RCA seminar on 'Ageing management of research reactors' 15
8. Seminar on information technology 16
9. BARC scientists honoured 16

ULTIMA 100+ : System Overview

Hardware

ULTIMA 100+ is based around an Industrial Personal Computer (IPC), which serves as the central controller. The electronics hardware constituents viz. Pulser/Receiver, Amplifier, Digitizer and Stepper Motor Controller are configured as a dedicated set of ISA bus compatible PC Add-on boards. A comprehensive menu driven software package has been developed in C language for implementation of data acquisition, storage, signal analysis & processing and information display. Installation of PC add-on boards and system software transforms the host PC into Ultrasonic Imaging System. Industrial PC has been specially chosen as the host because of several considerations. It provides a mechanically robust and environmentally rugged platform. Availability of a passive back plane with a large number of expansion slots and the CPU & associated hardware in the form of an 'Add-on Card' facilitate upgradation of the system as well as the host.

Fig. 1 shows a simplified block diagram of ULTIMA 100+.

The main functional blocks of the system are :

(1) The Pulser/Receiver.
(2) Broadband Amplifier.
(3) 100 Million Samples Per Second (MSPS) Digitizer.
(4) Three Axes Stepper Motor Controller for transducer positioning.

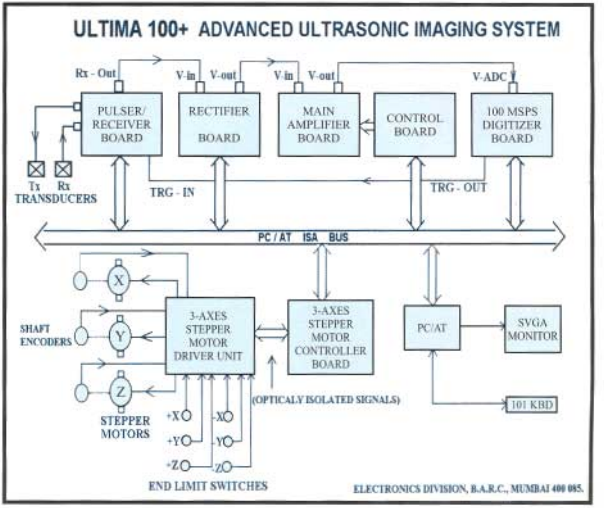


Fig. 1 : Schematic block diagram of ULTIMA 100+

Each block has been designed as a function specific PC Add-on card. Main advantages of such an arrangement are that the functional capabilities and performance features of the system can be selectively upgraded and the system can be easily tailored for meeting different application requirements.

Pulser-Receiver

The Pulser section generates the high voltage transmit pulse needed for the excitation of the ultrasonic transducer and it also amplifies the received echo signals. A high voltage MOSFET is employed for generating a voltage spike of approx. 300V amplitude, which energises the transducer. The sharp rise time (< 20 nsec) and narrow width (< 100 nsec) of the transmit pulse allows the use of pulse mode transducers over a frequency range of 1-20MHz.

Following modes of operation are supported:

(i) Pulse-Echo (PE) mode : In this mode, a single transducer serves both as the transmitter and receiver of ultrasound. This mode is the most commonly used type.

(ii) Transmit-Receive (T/R) mode : In this mode, two separate transducers are used so that one acts as the transmitter and the other as the receiver. This mode of operation is suitable for through-transmission investigations where the two transducers are geometrically aligned and face each other (with the test job in between). Such an arrangement is useful when the test objects are large and the material is attenuative or when pulse-echo methods are not suitable. However, more popular use of this mode is in investigations based on Time of Flight Diffraction (TOFD) Technique, which is widely used for detection and sizing of vertically oriented cracks typically encountered in welded joints. In some applications, the transmitting and the receiving transducers may be housed in a single probe assembly.

The pulse repetition rate of the Pulser is internally controlled by the master timing generator of the system for precise firing and well synchronized data acquisition. The desired rate can be selected by the user, under software control. Some of the user selectable parameters of the pulser are:

Pulser Enable	: On / Off
Transmit Pulse Amplitude	: 150 V / 300 V
Damping control	: 500/250/100/50 ohms

The RF echo signals sensed by the receiving transducer are routed to the receiver section for amplification. The receiver features a 3dB bandwidth of 40 MHz and 0 – 60 dB gain, adjustable in steps of 0.25dB. User selectable bandwidth limiting filters are also provided for optimising signal to noise ratio (SNR). The processed signal is fed to the main amplifier for further amplification.

Amplifier

The Amplifier board provides an additional gain of 40 dB with a 3dB bandwidth of 40 MHz. The gain can be set in steps of 0.25 dB giving the operator adequate flexibility for data collection. The amplified signal is buffered and routed to the Digitizer board for digitization and storage. In some applications, rectified echo signals are preferred over the RF echoes. To suit such applications, an additional rectifier PC Add-on board has been designed. It provides signal rectification in hardware.

Digitizer

The Digitizer board is the most crucial unit in ULTIMA 100+. It provides user selectable sampling rates of 100, 50, 25 and 12.5 MSPS to ensure flexibility and optimal data acquisition. High sampling rate (100 MSPS max.) allows use of high frequency transducers (even upto 20 MHz) that are necessary for improved resolution. The flash encoder samples the RF (i.e. the non-rectified) echo signals derived from the amplifier board to preserve the phase information. A record length of 8Kbytes is provided for storing one digitized A-Scan waveform. A programmable initial delay (w.r.t. the transmit pulse) is also provided for defining the region of interest and acquiring corresponding data. All these facilities allow the operator to acquire data in an uncompromising manner. The trigger signal (used

on the Pulser/Receiver board) is generated by the digitizer board and the same is validated by a sub multiple of the sampling clock. This ensures perfect synchronization between the transmit/receive operation and A-Scan digitization. Another useful feature provided with ULTIMA 100+ is 'Temporal Averaging of max. of 256 A–Scan Waveforms' Temporal averaging enhances the SNR, which leads to cleaner A-Scan waveforms and B/C- Scan images.

Stepper Motor Controller

For generating a B-Scan (representing vertical cross sectional view) or C-Scan (representing horizontal cross sectional view) image, it is necessary to have a well-controlled and precise movement of the transducer. One/two/three axes scanning assembly thus becomes necessary for obtaining ultrasonic images. The nature and complexity of the scanning assembly depends upon the size and geometry of the actual job. This in turn dictates the choice of the motor and associated drive electronics. Stepper motors provide a holding torque and can be controlled in a precise manner. Hence, they are an ideal choice for transducer positioning purposes. The stepper motor controller section, however, remains fairly standard and can be easily interfaced to the driver units of different types and capacities. A three axes stepper motor controller board has been developed for use with ULTIMA 100+. This board generates the basic 'step' and 'direction' signals needed for desired movement of the three stepper motors under software control and these signals can then be routed to the suitable driver unit designed at U.I. Section. In order to ensure the actual movement of the motor in response to 'step' input, shaft position encoders are generally employed as 'feedback sensors'. The controller board is equipped to accept such feedback signals and also the inputs from end limit switches for all the three axes. All the Input/Output signals are optically isolated for avoiding electrical noise and associated problems.

Scanning mechanisms employed for transducer positioning may be of two types:

i. Contact type and
ii. Water immersion type.

For contact scanning, test object must have very good surface finish and should be plane or cylindrical in shape. For other cases, immersion scanning is the only choice.

Software

The computational power of the host CPU can be fully exploited only if the data acquisition hardware is supported by a comprehensive and user-friendly software package. For the purpose of data acquisition, information display and signal analysis & processing with ULTIMA 100+, a dedicated menu driven software package has been developed. The present version has been developed in 'C' language and runs under DOS. 'Windows version' of this package is under development. This software enables the operator to select appropriate parameters for acquiring optimum data and presenting the information in a meaningful way. While storing each A-scan trace, all the associated parameters (such as Pulser/Receiver settings, sampling rate, amplifier gain, record length, initial delay, transducer angle & delay, material, velocity etc.) are also stored. This is extremely useful for future referencing or for repeat testing.

Salient software provisions are:

- Transducer parameter selection and coding
- Transducer calibration
- Material selection (in terms of velocity of propagation of ultrasound)
- Velocity measurement of an unknown material
- Mode selection (Pulse-echo or Transmit/ Receive)
- Pulser and Receiver Parameters selection
- Digitizer parameters selection
- Stepper motor controller parameters selection
- Acquisition mode selection (A, B or C)
- Cursor generation and manipulation for depth and amplitude measurements
- Signal processing : a) Selection of number of averages (for temporal averaging), b) Synthetic

Aperture Focusing Technique (SAFT), c) C-Scan slicing, and d) VI/Vt ratio calculation.

Applications

ULTIMA 100+ has been developed for NDT/NDE of different types of assembly parts. However, in ultrasonic testing, it is invariably necessary to follow specific procedures for inspection of jobs on hand. This may necessitate preparation of mock up, specifying the exact test procedure and establishing criteria for acceptance/rejection in accordance with the applicable defect standard. This demands a lot of skill and expertise on the part of the NDT personnel. Once the test procedure has been formulated, the technical features of ULTIMA 100+ can be exploited for obtaining best results. Some applications for which ULTIMA 100+ has been used effectively are briefly described below. The aim here is to highlight the diversity of applications rather than their details.

Development of ultrasonic testing technique for detection of uncracked zirconium hydride blisters in pressure tubes of PHWRs: ULTIMA 100+ was used at Atomic Fuels Division (AFD), BARC, for development of ultrasonic testing techniques for detection of uncracked zirconium hydride blisters in pressure tubes of PHWRs. The technique is based on different velocities of ultrasound in longitudinal and transverse modes (Vl & Vt resp.) in zircaloy and zirconium hydride. The study involves generation of B-scan image and carrying out measurement of velocity ratio (Vl/Vt) in a pressure tube sample-containing laboratory generated hydride blisters. Fig.2 shows the B-scan image of pressure tube with hydride blister using normal beam longitudinal wave technique.

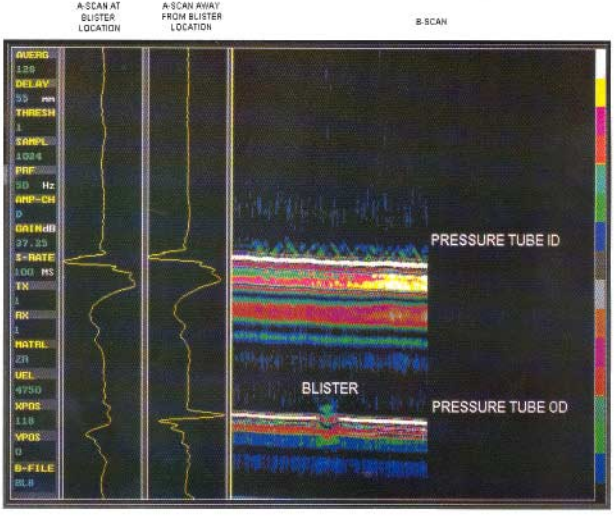


Fig. 2 : B-Scan image of pressure tube with hydride blister using normal beam longitudinal wave technique

Ultrasonic B-scan and C-scan imaging for flaw sizing : ULTIMA 100+ was used to generate C-scan images for quantitative assessment of lack of bond in brazed joint between silver (2mm thick) and copper (5mm thick) plates in electrical contactors. The C-scan image of reference samples confirmed the lack of bond at suspected locations. The size and shape of the regions featuring lack of bond in the image closely matched with those existing in the samples.

This system was also used to carry out ultrasonic testing of tube-to-tube sheet weld joints in heat exchangers. The initial trials have been successful and the results are encouraging. Both the above studies were carried out in association with the NDT experts of AFD, BARC. Fig.3 shows a C-scan image of the interface of a brazed contactor joint. Black regions (in the cyan portion of the C-Scan) are suggestive of lack of bond.

Fig.3 : B-Scan and C-Scan view of brazed contactor plates

Material Characterization by ultrasonic testing: ULTIMA 100+ was used at AFD, BARC to evaluate the soundness of Alumina-Zirconia-Silica (AZS) refractory blocks for measuring ultrasonic velocity and the variation therein. The reduction in velocity is attributed to the presence of shrinkage cavities/ porosity in the ceramic, and hence can be used for assessment of soundness of refractory block. B-scan and C-scan images were obtained by immersion scanning of these blocks using suitable transducers. Fig. 4 Shows B-Scan and C-Scan images of the AZS refractory block.

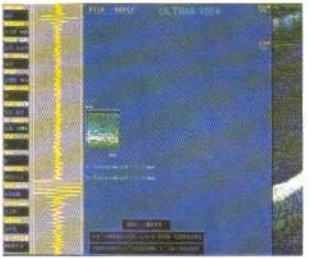


Fig. 4 : C-Scan Image of alumina-zirconia-silica ceramic block.

Sizing of thermal fatigue cracks in Feed Water Nozzles of Boiling Water Reactor : ULTIMA 100+ was used on three occasions during In-Service-Inspection of feed water nozzle at TAPS (unit 1 and unit 2) for sizing of thermal fatigue cracks. This inspection was carried out in association with the NDT experts of AFD, BARC, using Time Of Flight Diffraction (TOFD) technique. The trials for flaw characterisation using spectral analysis are to be carried out.

Inspection of Turbine Rotor at BHEL, Hyderabad : One ULTIMA 100+ system has been supplied to Metallurgy Department of BHEL, R&D, Hyderabad, on a commercial basis and it is used for inspection of Turbine Rotors.

Future Developments

ULTIMA is a generic name given to the Ultrasonic Imaging Systems being developed at Electronics Division, BARC, under the IXth Five Year Plan project. Different versions of ULTIMA are being developed.

- A multichannel system (ULTIMA 100M) is nearing completion. It provides a maximum of 8 independent Pulser/Receiver channels, which are controlled by a multi channel sequencer. The PC Add-on sequencer card has been developed and the integration of the first ULTIMA 100M is in progress.

- For applications requiring higher resolution, 'ULTIMA 200+' featuring a 200MSPS digitizer and an improved Broadband Pulsar/Receiver is being developed.
- When the test job and the inspection system cannot be operated in close proximity, long cables are needed for connection of transducers. This affects the transmit signal quality and degrades the SNR of received echo signal severely. To enhance the utility of ULTIMA systems in such situations, a remote "Pulser/Receiver unit" controlled by a host resident "PC Add - On I/O controller board" has been developed.
- Windows based system software is being developed for the entire ULTIMA series.

These developments are targeted to meet challenging inspection demands needed for a better Quality Control (QC) of a variety of engineering components.

Conclusion

ULTIMA 100+ is an advanced Ultrasonic Imaging System designed and developed at Electronics Division, BARC, for inspection of a variety of engineering components. It has been used for several applications at BARC as well as other organizations. This system is the first of its kind developed in India, and it is an outcome of a decade of sustained efforts of the developmental group at Ultrasonic Instrumentation Section, Electronics Division, BARC. Another significant achievement of this effort is the creation of a broad and solid R&D base that would enable development of more advanced and challenging Ultrasonic Instrumentation Systems in the future.

BARCIS 2000 SYSTEM READY FOR HANDING OVER TO NPCIL

Manjit Singh
Head, Division of Remote Handling & Robotics

Introduction

In-Service Inspection (ISI) of coolant channels of PHWRs is essential to provide assurance of continued structural integrity of pressure tubes over reactor life-time. A channel inspection system known as BARC Channel Inspection System (BARCIS 2000 system) for ISI of Madras Atomic Power Station (MAPS) coolant channels has been developed. The system is designed with the objective of minimising radiation exposure to inspection personnel and completion of inspection with minimum reactor down time. The overall system consists of an inspection head, a special sealing plug, a drive mechanism, a computerised control system, a CCTV system and inspection equipments. The existing fuelling machine (FM) has been used to load/unload the assembly of special sealing plug and inspection head into the coolant channel. This has resulted in substantial reduction in cost and complexity of the system. The successful completion of indigenous channel inspection system marks the development of critical technology and has resulted in substantial savings in foreign exchange. A prototype version of the system was developed in 1992. The prototype system was used for ISI of about 200 coolant channels of RAPS-2, MAPS-1 & MAPS-2. Based on the successful operation of the prototype system, NPCIL had requested BARC to supply two improved Mark-II systems for MAPS and one Mark-III system for NAPS at a total cost of Rs 5.50 crores. The first Mark-II improved system was supplied to MAPS in July, 97 (Ref. *BARC News letter No. 159, April 1997*). Mark-III system was supplied to NAPS in Jan 1999 (Ref. *BARC News letter No. 179, December 1998*).

The second Mark-II system (BARCIS 2000 system) incorporating improvements based on operational

experiences has now been developed. The improvements have been implemented in close co-ordination with MAPS. The inspection head has been improved to incorporate centering modules, load decoupler module, double universal joint and modular construction. These features help in improving the accuracy of inspection parameters. The drive mechanism and control system are designed to be industrially rugged for minimising maintenance requirements. A windows based operator friendly control system has been utilised. A quad CCTV system is used for remotised alignment, remotised calibration checking of linear and rotary displacements of inspection head and surveillance in FM vault during ISI. A dedicated computer compatible eddy current instrument for gap measurement has been developed and implemented. An anti-ejection device to eliminate the chances of inadvertent ejection of special sealing plug and blind flange to blank the channel in emergency conditions have been implemented. A facility for on-line calibration checking of ultrasonic transducers has also been implemented. Rotary mechanical stops are used to eliminate chances of damaging the transducer cables. The system has been extensively tested at full-scale mock-up test facility at BARC. The system is being despatched to MAPS.

Special Features of BARCIS Mark 2000 System

BARCIS 2000 system has following special features:

- Minimum overall size and weight of drive mechanism to simplify handling in FM vault.
- Improved sealing plug, anti-ejection device, drive tube guide module and drive tube to tube joint.
- Features for quick connection/disconnection of drive tubes with rotary gear box.
- Mechanical stops for rotary drive.
- Torque limiting coupling for linear and rotary drives.
- Non-contact position sensors for linear and rotary drives.
- Absolute encoders for linear and rotary position feedback.
- A windows-based operator friendly control system.
- Automatic logging of eddy current inspection data.
- Computer compatible NDT instruments.
- A facility for on-line calibration checking of ultrasonic transducers.
- Two way PA system for communication between FM vault and ISI control station.
- A quad CCTV system for
  - Remotised alignment of drive tubes in X and Y directions.
  - Remotised calibration checking of linear displacement of inspection head.
  - Remotised calibration checking of rotary displacement of inspection head.
  - Surveillance in FM vault during ISI.

System Capabilities

BARCIS 2000 system has the following capabilities:

- Ultrasonic measurement of wall thickness of pressure tube.
- Ultrasonic detection of flaws in longitudinal and circumferential directions in pressure tube.
- Eddy current detection of garter spring location and tilt.
- Eddy current estimation of annular gap between pressure tube and calandria tube.
- Eddy current detection of flaws in longitudinal and circumferential directions on inner surface of pressure tube.

Operator Training

Using this system, training for operators from NAPS, KAPS, MAPS, RAPS and NPCIL Head Office was conducted at BARC during the period from July 17 to 27, 2000. Dr Anil Kakodkar, Director, BARC, inaugurated the training course and addressed the participants. The training course consisted of lectures, demonstrations, practice sessions, discussions and qualification examination. Mr Ch. Surendar, Chairman & Managing Director, NPCIL,

Dr Anil Kakodkar, Director, BARC, inaugurating operator training course for BARCIS 2000 System

presented the qualification certificates to the operators on completion of the training programme A total of 44 operators were qualified in the course Mr G. Govindarajan, Director, Automation & Manufacturing Group and Electronics & Instrumentation Group, BARC, presented BARCIS 2000 system manuals to Mr Ch. Surendar, Chairman & Managing Director, NPCIL.

Participating Agencies

Division of Remote Handling & Robotics has been responsible for the development of inspection head, drive mechanism, computerised control system, eddy current gap measurement, quad CCTV system and computer compatible NDT instruments. Atomic Fuels Division has been responsible for the development of inspection techniques. Refueling Technology Division has been responsible for the development of special sealing plug and in-head calibration plug. CWS has helped in machining parts of special sealing plug and in-head calibration plug.

Advances in BARCIS

Under IX-Plan project " Development of Tools & Techniques" (Power-6), the following advanced technologies are being persued at Division of Remote Handling & Robotics:

- Ultrasonic measurement of ID, OD and WT of pressure tubes.
- Ultrasonic imaging of zirconium hydride blisters in pressure tubes.
- Miniature underwater radiation resistant CCTV camera for visual inspection.

Mr G. Govindarajan, Director, AMG & EIG, BARC, presenting BARCIS 2000 System manuals to Mr Ch. Surendar, CMD, NPCIL

A computer-based four channel ultrasonic dimensional measuring system has been developed for measurement of ID, OD & WT of pressure tube. The system has a resolution of measurement of one micro-meter and overall accuracy of ten micro-meters.

Experiments for detection of zirconium hydride blisters are being conducted. It has been possible to detect one millimeter diameter blister using amplitude of reflected shear wave. Further experiments to qualify the technique for field use are on hand.

Development of an advanced miniature underwater radiation-resistant CCTV camera suitable for delivery by BARCIS is in progress. Prototype optical and electronic components for the camera have been developed and are undergoing irradiation testing. The components are being qualified for use in radiation field of 10^6 Rads/hr for an integrated dose of 10^8 Rads.

These technologies shall be implemented in the future version of BARCIS. The technologies can also be retro-fitted in earlier BARCIS systems supplied to NPCIL.

REMOTE REPAIRS TO HELIUM PIPE FLANGE JOINTS INSIDE CIRUS PILE BLOCK

A novel remote repairing method was developed to stop the helium leak from eight numbers of tongue and groove flange joints of helium cover gas system connected to Cirus calandria. The flanges are located in a 200 mm gap within the reactor core structure at a depth of 4 metres from top of pile and are not approachable.

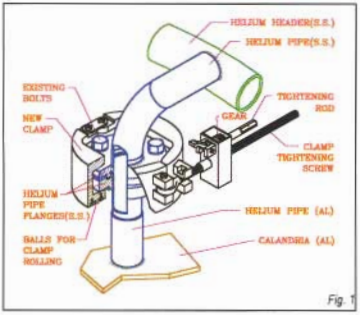


Fig. 1

The remote repairing method involved design and fabrication of split sealing clamps with tapered inner faces, which are made to press against both the helium pipe flanges by clamp tightening, thereby achieving the leak tightness. Detailed piping analysis using computer code Caesar - II was carried out by Reactor Safety Division (RSD), BARC, to finalise the extent and sequence of clamp tightening.

Remote operated clamp tightening tools were developed and the tools and clamps were calibrated. The complete procedure was qualified at a specially erected mock up station. The remote viewing was achieved by inserting two video cameras through pile holes to the flange location and connected to video monitors located on top of pile. The clamps and cameras were manoeuvred through pile holes like marionette using nylon strings. The clamps were fixed and tightened on the leaky flanges by remote viewing.


Fig. 2

After tightening of 4 out of 8 flange joints, the helium leak has reduced. Further tightening of the clamps is in progress. The remote repairing of flange joints is being carried out by Reactor Group, BARC.

INAUGURATION OF NEW ANALYTICAL FACILITIES OF CHEMICAL ENGINEERING DIVISION

Chemical Engineering Division, BARC, has been operating various stable-isotope-separation plants on pilot scale since past 20 years, and hence isotopic and trace analysis of various process streams has been one of the prime analytical needs. After setting the higher targets in IX plan, there has been a sudden overall growth in these activities, resulting in a sharp rise in analytical needs with respect to isotopic and trace analysis. In addition to this, demands on trace analysis of different steels, alloys (like monel, inconel, etc.) and other metals and chemicals being procured, have also grown considerably.

In order to cope with these enhanced analytical demands, it was essential to procure certain state-of-the-art analytical instruments. Subsequently, two state-of-the-art instruments, viz. Thermal Ionization Source Mass Spectrometer (TIMS) and computer controlled double beam Atomic Absorption

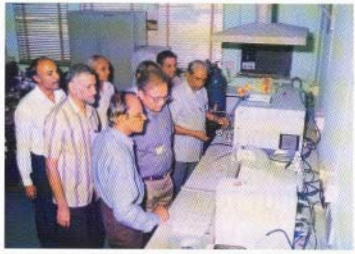
Mr B. Bhattacharjee, Director, Chemical Engineering & Technology Group, BARC, and Dr V.C. Sahni, Director, Physics Group, BARC, inspecting the TIMS unit after its inauguration. Accompanying them are Mr S.K. Ghosh, Head, Chemical Engineering Division and other officers of ChED and TPPED

Spectrophotometer (AAS) along with graphite furnace and hydride generator attachments have been procured and installed. Briefly given below are the main features and analytical capabilities of both the machines.

Thermal Ionization Mass Spectrometer (TIMS)

This machine has been designed, developed and fabricated fully within BARC by Technical Physics & Prototype Engineering Division (TPPED), with over 80% of the necessary materials and components being procured indigenously by Chemical Engineering Division as per the designer's specifications. TIMS has a triple filament ion source, stigmatic focusing magnetic analyzer geometry and three faraday collectors for simultaneous collection of ion beams. This machine is now ready for isotopic ratio measurements of the samples (like Boron-10 and other isotopes up to mass no.100) generated from the plant and other R&D activities, on routine basis. This new facility shall also be gainfully utilised for carrying out R&D work like study on isotopic effect observed during analysis w.r.t. time, studies on analytical sensitivity using different filament materials in source assembly, etc. Some of the main features of the machine are given below.

(a) Source: Triple-filament-assembly, *(b)* Magnetic field strength: 8K Gauss, *(c)* Radius of curvature: 15cm., (with stigmatic focusing, the effective radius is 30cm.), *(d)* Accelerating voltage : 5KV, *(e)* Mass range: I to I00 amu (extendabie to higher masses by working at lower accelerating voltage), *(f)* Precision: ± 0.1% at 1σ for natural Boron, *(g)* Resolution: 200 with 10% valley, *(h)* Measurement range: I to 99 atom%, *(i)* Detector: Faraday cup, *(j)* Data system: Windows 95 based software for peak scanning, peak overlap and display on screen for ratio and other relevant parameters.



Mr M.K. Dixit of Chemical Engineering Division briefing Mr B. Bhattacharjee, Director, ChE & TG about the new AAS unit. Accompanying him is Dr V.C. Sahni, Director, Physics Group, BARC

Double Beam AAS

A state-of-the-art atomic absorption spectrophotometer model AVANTA PM has been procured from M/s GBC Scientific Equipment Pvt. Ltd., Australia. This double beam machine has some very special features, like asymmetric modulation (for improved S/N ratio), fast background correction (for achieving highly accurate absorbance readings), automatic burner rotation (for accommodating concentrated samples), and powerful grating (for better resolution), that make it stand out among various models available in the market. With its graphite furnace and hydride generator attachments, the machine is capable of analysing about 70 elements, thus increasing the analytical capabilities of the Division. Some of the main features of the machine are summarized below.

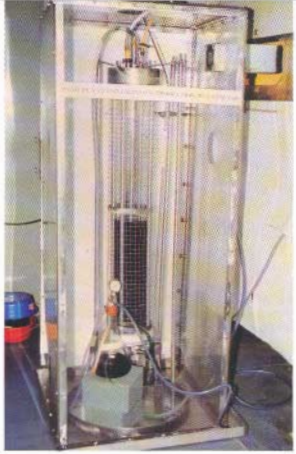
(a) Model: AVANTA PM, *(b)* Optics: Double-beam, *(c)* Wavelength range : 185-900 nm, *(d)* Mounting: Ebert-Fastie, *(e)* Monochromator: Diffraction grating ruled with 1800 lines/mm and blazed at 254 nm, *(f)* Slit: Continuously variable from 0.2-2.0 nm w.r.t. width and height, *(g)* Lamps: Computer controlled 8 lamp turret, *(h)* Focal length: 333 mms, *(i)* gas flow: Computer controlled gas flow with interlock safety

features, *(j)* Provision of auto-sampler along with graphite furnace module, *(k)* Provision of hydride generator module, *(l)* Software: Windows- 98 based software for controlling various operating parameters and display of relevant data on the screen.

A NON-ELECTROLYTIC ROUTE FOR THE PRODUCTION OF URANOUS NITRATE SOLUTION AS AN INPUT TO PUREX PROCESS

In the spent fuel reprocessing by PUREX process, U(VI) & Pu(IV) are co-extracted from nitric acid by the extractant TBP leaving the bulk of the fission products in the aqueous stream. The extracted uranium and plutonium are separated from each other by reductive stripping of Pu(IV) to Pu(III), which is poorly extracted by TBP. Conventionally, uranous nitrate in nitric acid is used as a reducing agent for this purpose in the presence of hydrazine nitrate as stabilizer. Generally, it is produced by electrolytic reduction of uranyl nitrate, which has certain drawbacks like difficulties in 100% conversion, electrode life, etc. At BARC, a procedure has been developed and standardized for producing 100 % uranous nitrate by reducing U(VI) with H_2 gas in presence of hydrazine and finely divided PtO_2.

Based on the laboratory studies, a reduction column with 20 litres capacity was designed, fabricated at the workshop of Fuel Reprocessing Division and installed with all the required safety features to handle H_2 gas and actual plant uranium product solution for generation of U(IV). The plant uranyl nitrate solution is used after treatment with a polystyrene divinyl benzene polymer matrix (without any functional group) to remove the dissolved organics and to avoid frothing during reduction. The column experiments have been conducted with 5 litres of 100 g/l uranium solution in 1-2 M HNO_3 with 0.5 M hydrazine nitrate as stabilizer. The column has been standardized for operation with H_2 (8%)-N_2 gas mixture, though it is designed for the safe utilization of 100% H_2 gas also. The results indicate that 100% conversion of U(VI) to U(IV) can be achieved in 60 or 15 minutes depending on whether 8% H_2 in N_2 or 100% H_2 is used. Another major breakthrough achieved in these experiments being conducted at Process Development Division is the possibility of near quantitative reduction of uranyl nitrate even in the absence of H_2 with hydrazine alone as reductant in less than four hours under similar conditions. This reveals the flexibility and potential of this technique for its application in the fuel reprocessing streams. It is felt that this development can greatly facilitate the reprocessing plant operations.

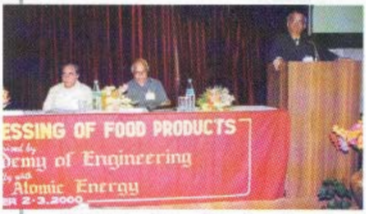


Pilot plant for uranous nitrate production by catalysis

INAE-DAE SEMINAR ON 'RADIATION PROCESSING OF FOOD PRODUCTS'

A seminar on 'Radiation Processing of Food Products' was organized by Indian National Academy of Engineering (INAE) jointly with

Department of Atomic Energy (DAE) at the Multipurpose Hall, Training School Hostel, Anushaktinagar, Mumbai, during November 2-3, 2000. Nearly 300 delegates from food industry, Mumbai university and different DAE units participated in the seminar. The seminar was organised to explain different aspects of radiation processing technology for food and agricultural commodities and to take note of views/ comments/suggestions expressed by invited speakers and participating delegates.



Dr Anil Kakodkar, Chairman, Atomic Energy Commission and President of INAE, addressing the participants at the INAE-DAE Seminar on 'Radiation Processing of Food Products'

Dr Anil Kakodkar, President of INAE and Chairman, AEC, welcomed the participants. In his presidential address, Dr Kakodkar stressed on the need to take the radiation processing technology for food preservation to the masses by promoting consumer awareness. He expressed his satisfaction at the working of spice irradiator at Vashi, Navi Mumbai, and also appreciated the efforts being made by BARC to construct demonstration plants for radiation processing of onion, potato and other low dose requiring products (POTON) at Lasalgaon in Nashik District of Maharashtra.

In his keynote address, Mr Omesh Saigal, Secretary, Department of Food Processing Industries, Ministry of Agriculture, New Delhi, gave an account of food and agricultural scenario in India. He lamented that India's share of processed food in world trade is less than 2% though it is a leading producer of both fruits and vegetables. Citing losses of fruits and vegetables between 10 to 36%, Mr Saigal stressed the importance to develop suitable

Mr Omesh Saigal, Secretary, Department of Food Processing Industries, Ministry of Agriculture, New Delhi, addressing the participants

food processing technologies particularly to reduce wastage, while simultaneously improving storage and transportation facilities. He lauded the extensive R&D work done by BARC on radiation preservation of food, resulting in the clearance by Ministry of Health and Family Welfare under Prevention of Food Adulteration Act of a number of food commodities of both plant and animal origin. He said that the Department of Food Processing Industries has taken an initiative to propose an Act to provide a single window system so that the approval under PFA is streamlined for induction of new innovations, such as radiation processing of food in the food processing sector. Finally, he opined that to generate appropriate impact of radiation processing technology, more efforts are required in the form of practical demonstration on commercial scale to farmers, traders, cooperatives, marketing personnel and public at large.

Dr U.B. Pandey, Director, NHRDF, Nashik, surveyed the production scenario of onion and garlic in India and said that the demand for these two crops is expected to be doubled in the next 10 years. Since there are limitations on production of onion and garlic due to requirement of land for other crops, he advocated the use of radiation processing technology to prevent losses of these valued commodities and thus make them available to consumers in sufficient quantities round the year.

Dr V. Prakash, Director, CFTRI, Mysore, stressed the need to have an integrated approach towards

radiation processing technology of fruits and vegetables.

Dr S.N. Potti, Director, Research, ICRI, Idukki, Kerala, appealed to spice exporters to adopt radiation processing technology to decontaminate spices meant for export as this technology has shown added advantage over the conventional methods adopted in India. He also suggested to undertake consumer awareness program and the need to develop proper packaging material to avoid post-irradiation contamination of spices.

Dr A.K. Sharma of Food Technology Division, BARC, outlined the scientific aspects of radiation processing of food products. He said that efforts are being made at all levels to remove misconception about this technology. He assured that the Department of Atomic Energy has the requisite scientific and technical know-how and that radiation processing technology can help the nation in strengthening food security, improving food safety, and boosting agricultural exports.

Mr H.C. Soni from Centre for Advanced Technology, Indore, while citing the advantages offered by radiation processing of food by Co-60 gamma radiations, opined that the demand for high processing throughput can justifiably be met by using electron accelerators, an alternate radiation generating source.

Dr D.R. Bongirwar, Convener of the symposium and Head, Food Technology Division & Project Manager, Food Irradiator Project, BARC, reviewed the infrastructure facilities for radiation processing of food plants. He gave a brief description of plants for radiation processing of food including infrastructure requirements, design and process control. Mr D.S. Lavale of the Board for Radiation & Isotope Technology, DAE, presented the conceptual design and economic analysis of a two conveyor, multi-product, Co-60 based radiation processing plant, a multi-tasking radiation processing facility . He also described the advantages such a plant would offer in utilising efficiently the radiation source and its economics.

Dr K. Gopkumar, DOG (Fisheries), ICAR, New Delhi, expressed that radiation preservation of seafood offers excellent scope for supplying safe and wholesome food to people. The introduction of radiation processed seafood in Indian market can start with patients in hospital, followed by selective markets. Simultaneously, people should be made aware of the consequences of eating contaminated food.

Participants of the Seminar tasting the edibles preparéd from irradiated potatoes

At the end of the invited talks, a panel discussion was held. Mr B.K. Aggarwal, IAS, Commissioner, FDA (Maharashtra State), moderated the discussion. Panelists (Mr P.K. Ghosh, Dy. Director, AERB, DAE, Dr. Ram Gopal, Director, Defence Lab, Jodhpur, Prof. Sherikar, Bombay Veterinary College, Mumbai, Dr R.B. Grover, Technical Adviser to Chairman, AEC, Prof. J. Pai, UDCT, Mumbai, Dr V.S. Rao, Food Technology Division, BARC and Dr S. Ayyappan, Director, CIFE, Mumbai, expressed their respective views about radiation processing technology and answered the points raised by the delegates. Though all the participants were assured of the benefits of the radiation processing of food, it was felt that the awareness of its safety needs to be propagated properly, like through educational institutions, co-operatives, etc.

Dr. D.V. Singh, Fellow, INAE and Vice Chancellor, University of Roorki, gave vote of thanks on behalf of the delegates.

IAEA/RCA SEMINAR ON 'AGEING MANAGEMENT OF RESEARCH REACTORS'

An IAEA/RCA Seminar on 'Ageing Management of Research Reactors' was organised by the Reactor Group of BARC during December 4-6, 2000 at the Homi Bhabha Centre for Science Education, Mumbai, and was attended by 44 participants from Australia, Bangladesh, Brazil, China, Germany, India, Indonesia, Malaysia, Philippines, Republic of Korea, Thailand, Vietnam and IAEA.

Dr Anil Kakodkar, Chairman, AEC, delivering the inaugural address at the seminar.

The Seminar was inaugurated by Dr Anil Kakodkar, Chairman, AEC. In his inaugural address, Dr Kakodkar observed that a large number of research reactors in the world have aged considerably and, therefore, the subject of ageing management has gained great importance. This fact has prompted the International Nuclear Safety Advisory Group to recommend to the IAEA that special efforts are necessary for ensuring safety of these reactors through appropriate ageing management actions. He stated that detailed ageing studies were conducted for the Trombay research reactor, CIRUS, after it completed three decades of operation. Elaborate refurbishing plans were drawn up based on these studies and an extended outage of the reactor was then taken to execute the required actions. Refurbishment of CIRUS is now nearing completion and it is likely to go back into operation during the coming year. In this context, conduct of this seminar here was appropriate and timely, he said. Mr. Francisco Alcala-Ruiz of IAEA gave an account of the work being done at IAEA in the area of safety of research reactors including ageing management. Mr S.K. Sharma, Director, Reactor Group, BARC delivered the welcome address and Mr S. Sankar, Associate Director, Reactor Group, BARC, proposed the vote of thanks. The seminar had 6 keynote addresses by speakers from Australia, Brazil, Germany, India, Indonesia and IAEA and 24 contributed papers. Topics covered in the presentations included Ageing management of structures and components, Control and Instrumentation, In-Service Inspection & Surveillance, Ageing Assessment and Life Extension and Safety & Surveillance aspects of ageing Management of research reactors. Indian participants presented 13 papers covering ageing management aspects of APSARA, CIRUS and FBTR. A technical visit to BARC, facilities was also organised for the participants.

Mr F. Alcala-Ruiz of IAEA speaking at the inaugural function of the IAEA/RCA Seminar on Ageing Management of Research Reactors. Seated on the dais are (left to right), Mr S. Sankar, Associate Director, Reactor Group, BARC, Dr Anil Kakodkar, Chairman, Atomic Energy Commission, and Mr S.K. Sharma, Director, Reactor Group, BARC.

The Seminar was followed by a two-day Project Review Meeting attended by RCA Project Co-ordinators for Research Reactors from 10 countries in Asia Pacific region and 2 IAEA officials. The meeting reviewed the work done under the project during 1999 and 2000, finalised work plans for the

2001-02 cycle and prepared an outline of proposals for 2003-04. As per the plan for next two years, a Regional Training Course on In-Service Inspection of Research Reactors is scheduled to be held in Mumbai during January 2001.

SEMINAR ON INFORMATION TECHNOLOGY

On the occasion of closing ceremony of Golden Jubilee year of the official language and Hindi Day on September 14, 2000, Hindi Vigyan Sahitya Parishad, BARC, organised a Hindi Seminar on Information Technology at BARC. The seminar was inaugurated by Prof Sukhatme, Chairman, AERB, and presided over by Mr B. Bhattacharjee, Director, ChETG & Chairman, OLIC, who appealed to staff members to do more and more official work in Hindi. Over two hundred eighty staff members from technical, auxiliary and administrative streams participated in the Seminar.

Prof. Sukhatme, Chairman, AERB, releasing a book in Hindi on "Indian Atomic Energy programme (50 years)"

Mr H.K. Kaura, Mr P.S. Dhekne, Mr A.G. Apte, Dr N. Raj, Dr S.P. Kale and Mr V.K. Chaddha, delivered lectures in very simple Hindi on various applications of Information Technology. Participants showed keen interest in IT application in Communication, Security, Medicine and Agriculture.

BARC SCIENTISTS HONOURED

♦ Dr. Anil Krishna Debnath of Technical Physics and Prototype Engineering Division, BARC, has been selected for the award of 'Best Prototype Prize' for H_2S gas sensor along with control and display electronics, presented at the exhibition in 7th National Seminar on Physics and Technology of Sensors held at Pune University during February 14-16, 2000. The award carries a cash prize and a citation.

♦ Dr Vinod Kumar Aswal of Solid State Physics Division, BARC, has been elected as a Young Associate of the Indian Academy of Sciences for the period 2000-2005. Dr Aswal has been working in the field of Small-Angle Neutron Scattering (SANS) studies on micellar solutions of conventional surfactants, Gemini surfactants, block co-polymers, mixed surfactants, and surfactants with multiple head groups. He has extensively published results of his research work in highly reputed National and International scientific journals, and presented papers at various Conferences. Honors and prizes, received earlier by Dr Aswal, include Homi Bhabha Award for securing the first rank in physics of 36th batch of Training School, and the Best Thesis Presentation Prize given at the 42nd DAE Solid State Physics Symposium held at Kalpakkam during December 1999.

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