बीएआरसी न्यूज़लैटर
BARC NEWSLETTER

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IN THIS ISSUE

In the forthcoming issue

^{177}Lu-EDTMP: a new radiopharmaceutical for palliation of bone pain in cancer patients with skeletal metastases

Conventional treatment methods for alleviating bone pain and other symptoms in cancer patients, involve multiple side effects. Radionuclide therapy, employing radiopharmaceuticals labeled with radionuclides and which emit β^-/conversion electrons is an effective alternative.

The Radiopharmaceuticals Division, has developed a new radiopharmaceutical ^{177}Lu EDTMP, for bone pain palliation. It is particularly useful in the Indian context as it is cost effective, can be prepared in moderate flux reactors and has a comparative longer half-life, for transportation to distant locales.

The production of ^{177}Lu, the synthesis and characterization of its carrier legend EDTMP, the preparation of the final product and its quality control parameters have been detailed in this article. After preliminary studies on animals, pre-clinical trials on human patients were also successfully carried out.

CONTENTS

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DEVELOPMENT OF DISPERSIVE EXTENDED X-RAY ABSORPTION FINE STRUCTURE (EXAFS) BEAMLINE AT INDUS-2 SYNCHROTRON SOURCE

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Extended X-ray absorption fine structure (EXAFS) technique, enables the measurement of fine structures in the X-ray absorption spectra, above the absorption edge of the atoms in a material. Generally an EXAFS spectra extends from ~100 eV below the absorption edge of the particular atom, to ~700 eV above the absorption edge. The spectrum near the absorption edge (viz., the XANES part), gives information about the long range order existing in the sample and the oxidation states of the atoms involved, while the part of the spectrum well above the absorption edge (the EXAFS part) gives information regarding the short range order and local structure around the atomic species. With the advent of modern bright Synchrotron radiation sources, this technique has emerged as the most powerful technique for local structure determination, which can be applied to any type of material viz. amorphous, polycrystalline, polymers, surfaces and solutions.

EXAFS measurements with synchrotron radiation are generally carried out in two different modes viz., scanning and dispersive. In the scanning mode, the beamline uses a Double-Crystal – Monochromator (DCM) to select a particular energy from the incident synchrotron beam, which is incident on the sample and the intensity of the transmitted beam passing through the sample or that of the fluorescence beam emerging out of the sample is recorded along with the incident intensity at each energy by scanning the DCM crystals. In the dispersive mode, a bent crystal polychromator is used, to select a band of energy from the white synchrotron beam, which is horizontally dispersed and focused on the sample. The transmitted beam intensity from the sample is recorded on a position sensitive CCD detector, thus enabling recording of the whole EXAFS spectrum around an absorption edge in a single shot.

The beamline described here works in the dispersive mode using a 460 mm long Si (111) crystal mounted on an elliptical bender and a position sensitive CCD detector having 2048 x 2048 pixels. The beamline is designed to cover the photon energy range of 5 to 20 keV providing energy band widths of 0.3 keV, 1.0 keV and 2.0 keV and with resolutions of ~ 0.5 eV, 1 eV and 2 eV per pixel at photon energies of 5 keV, 10 keV and 20 keV, respectively. A schematic

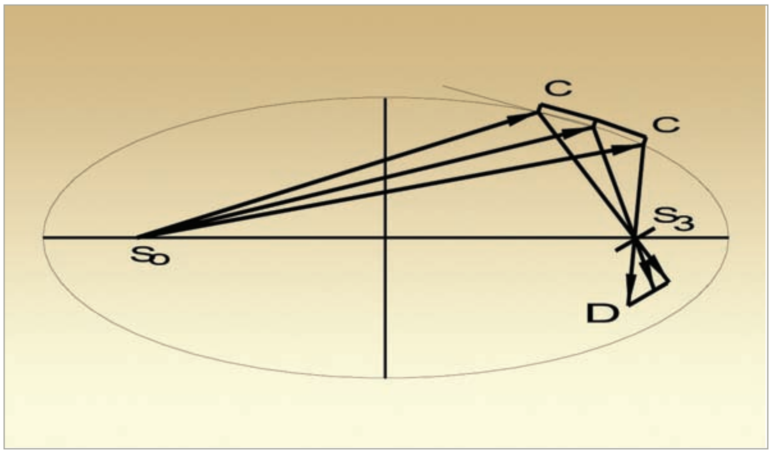

Fig. 1: Working principle of the dispersive EXAFS beamline

of the beamline is shown in Fig.1. Here, a bent single crystal (C,C) forms part of an ellipse such that, the source (S_0) and the sample positions (S_3) are situated at two foci of the ellipse. The elliptical optics ensure that radiation emerging from one focus (S_0) to reach the other focus, (S_3) after reflection from the crystal and offers minimum aberration.

Optical Lay-out of the beamline

The optical layout of the beamline is shown in Fig. 2. The emission from the synchrotron source is first passed through a Be window (B) of suitable thickness, to cut-off the unwanted low-energy part from the continuum and then through the beam aperture system consisting of two copper blocks (K,K), positioned at an angle of 15° to the beam path for collimation. The collimated beam with horizontal divergence of 1.5 mrad is then made to fall on the slit system (S,S) which defines the final horizontal and vertical divergence of the synchrotron beam, using two sets of water-cooled tantalum jaws. The beam emerging from the slit system with required vertical and horizontal divergences falls on vertically focusing mirror (M,M) at a grazing angle of incidence ~0.2° which cuts-off the higher energy part of the synchrotron beam. After reflection from the mirror, the beam falls on silicon crystal (C,C) mounted on a bender. Depending on the angle of incidence of the beam and its radius of curvature, the crystal reflects a particular central energy (E_o) with a certain band-width (ΔE) and this spatially dispersed polychromatic radiation, is focused at the sample

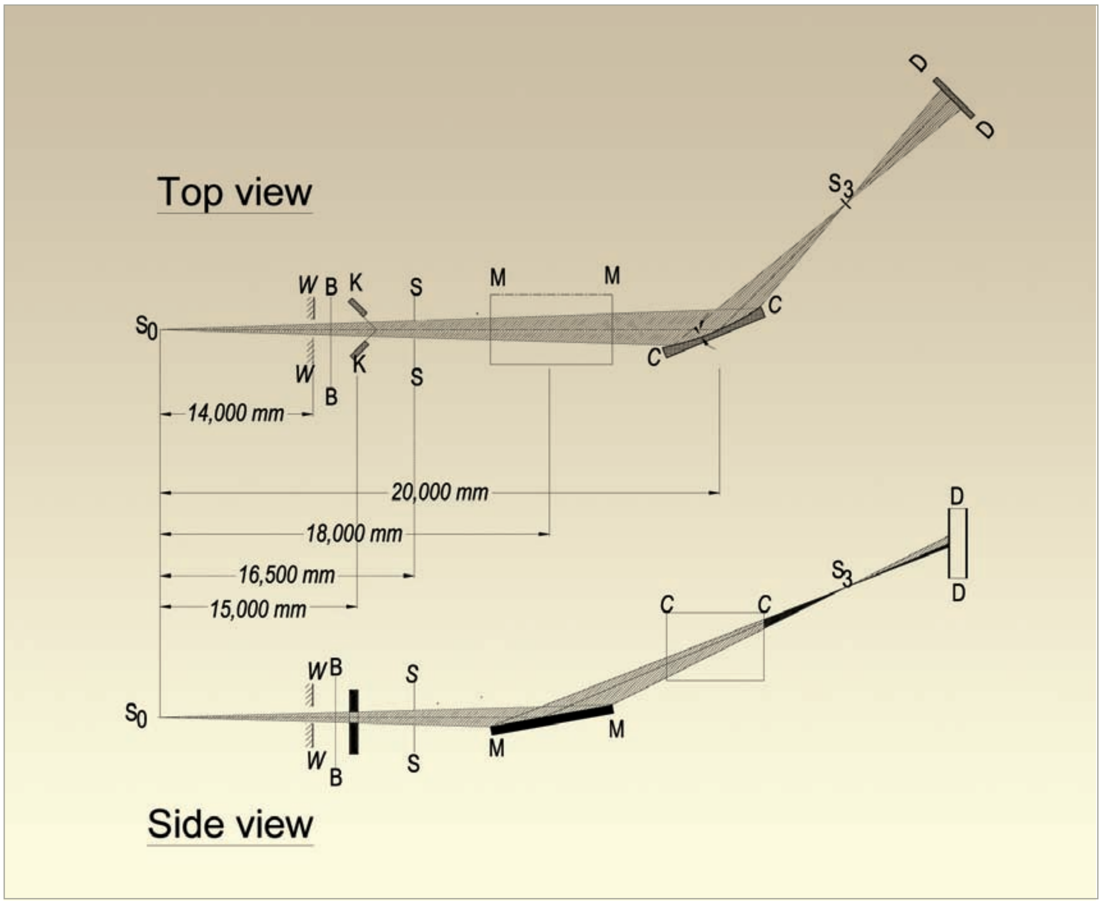

Fig. 2: Optical lay-out of the dispersive EXAFS beamline

position (S_3). The transmitted radiation from a sample diverges further and is detected by a position-sensitive detector (D,D). Thus, the energy dispersed absorption spectra of the sample over the whole band width (ΔE) around the central energy (E_0) can be simultaneously recorded by the detector.

Mechanical Lay-out of the beamline

The mechanical layout of the beamline is shown in Fig. 3. The two beam view chambers shown in the figure are used, for periodic monitoring of the beam path, by stopping the beam on a graduated scintillation screen and viewing the position of the visible spot, generated through a digital camera mounted on the view port of the chamber. The first Be window isolates the beamline from the front-end, while the second Be window isolates the UHV portion of the beamline from the polychromator chamber, where the crystal bender is kept at lower vacuum (~10^{-3} Torr). The indigenously developed crystal bender, works on the principle of four point bending which ensures desired curvature on one plane and prevents twisting of the crystal in the other plane, which is detrimental to Bragg reflection. The elliptical curvature on the crystal surface can be achieved by the above process, provided the moment of inertia of the crystal is varied over its length in a particular fashion and for this purpose, a profiled crystal with variable height has been used in this case. The polychromator chamber is isolated by another Be window at its exit port from the rest of the experimental station which is in air. The experimental station basically consists of a large goniometer, with the crystal bender chamber mounted on its θ axis while the sample and detector stages are mounted on the 2θ arm. Both the sample and detector stages are provided with stepper motor controlled X-Y-Z and tilt stages for precision alignment and the whole 2q arm of the goniometer is capable of translational and rotational movement on air pads, on a granite slab of dimension 3m length x 4m width and having a surface finish ~25 µm. A secondary slit system is used, prior to the crystal bender to selectively illuminate different portions of the crystal and thus to optimize the bending profile, so that, rays from different portions of the bent crystal, fall on the same focal spot.

The heat loads being dumped by the Synchrotron radiation on various components of the beamline viz., the beam aperture system, slit system, mirror system and the polychromator crystal, have been estimated from the power spectrum of the INDUS-2 source, for its full beam current level of 300 mA. Accordingly, suitable arrangements for cooling have been devised for each of the components.

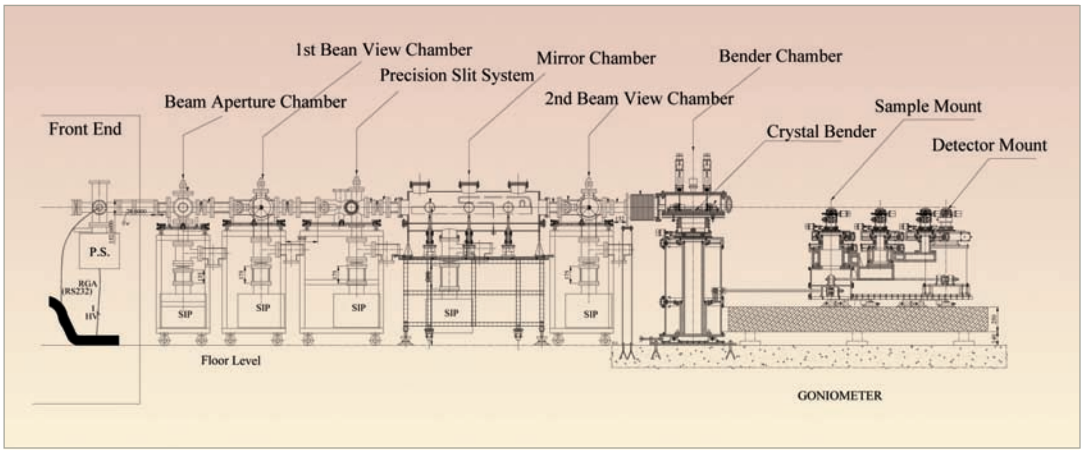

Fig. 3: Mechanical lay-out of the dispersive EXAFS beamline

In the entire beamline, the vacuum achieved is better than 10^{-9} Torr. A shielding hutch is provided around the beamline with a 2mm thick lead sheet to maintain the radiation level outside the hutch area within the allowed limit of 0.12 μSvh^{-1}. The hutch design was theoretically verified using the EGS4 (Electron Gamma Shower) Monte Carlo code, prior to its construction and later experimentally by mapping the radiation dose. A 150 mm thick lead brick wall is used at the end of the beamline, to stop the gas Bremsstrahlung which may pass through the beamline from the Synchrotron storage ring. Photographs of the beamline components inside and the control consol outside the shielding hutch after final installation are shown in Figs. 4 (a) and (b), respectively. Photographs of the 19-axis goniometer and the crystal bender indigenously developed in collaboration with CDM, BARC are shown in Fig. 4(c) and (d) respectively.

Fig. 4(b): Photograph of the control consol and shielding hutch of the dispersive EXAFS beamline

Fig. 4(c): Photograph of the 19-axis goniometer developed in collaboration with CDM, BARC

Performance evaluation and calibration

Fig. 5 shows the synchrotron beam spot on a CCD screen focused horizontally by the crystal bender and vertically by the mirror at the sample position for 20000 eV setting of the crystal bender and goniometer. With the setup, a horizontal focal spot of 200 mm (FWHM) is achieved. Beyond the sample position the beam diverges further and fills the CCD at the detector position. The beamline performance has been studied

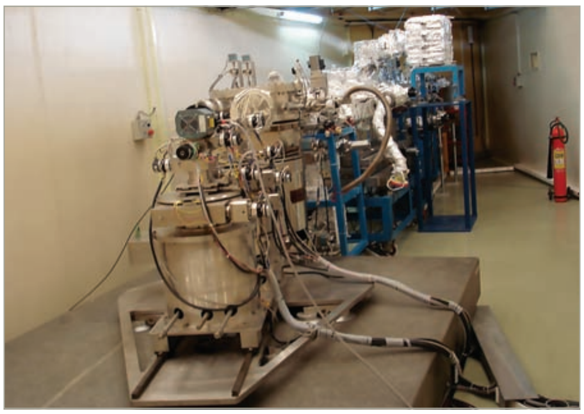

Fig. 4(a): Photograph of the dispersive EXAFS beamline installed at BL-8 port of INDUS-2

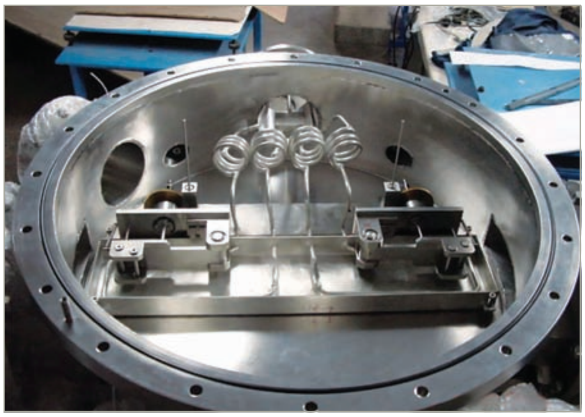

Fig. 4(d): Photograph of the crystal bender assembly developed in collaboration with CDM, BARC

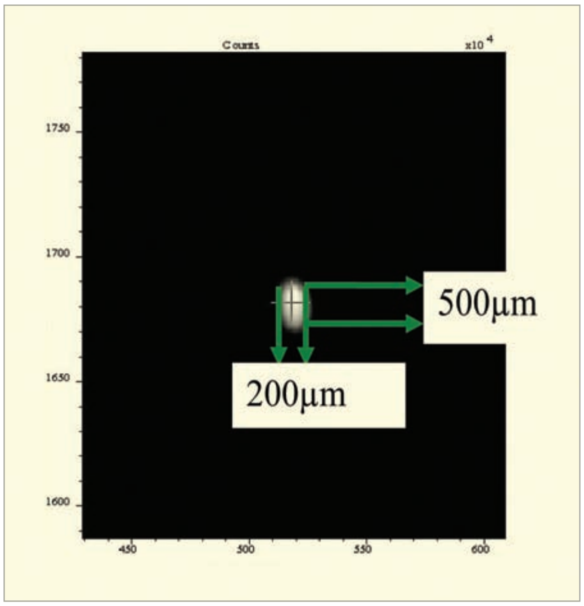

Fig. 5: Photograph of the focus spot at sample position

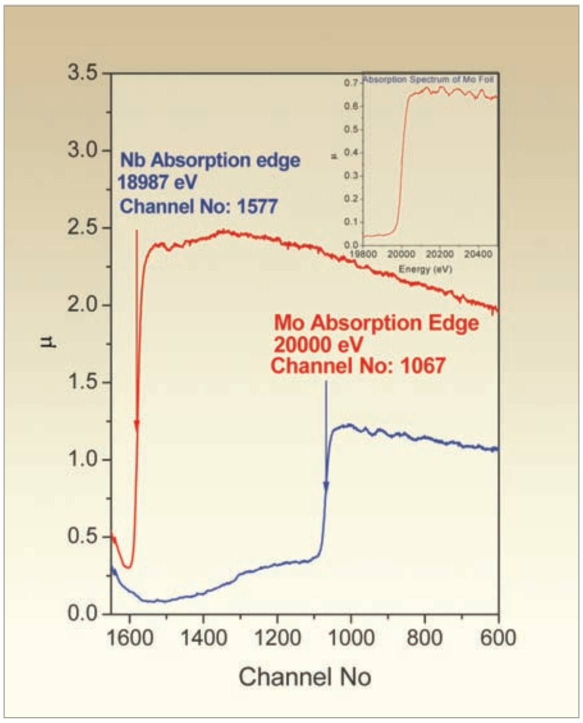

Fig. 6: Calibration of CCD channels by recording of Mo and Nb absorption spectra under same setting of goniometer and crystal bender (Inset shows the Mo EXAFS spectrum in calibrated energy scale)

by measuring the absorption spectra of some standard foils and oxide powders. The absorption edges of 99.99% pure Mo and Nb foils recorded under the same setting of crystal bender and the goniometer, are shown in Fig. 6, where the absorption edges of Nb and Mo are found to appear at CCD channel numbers 1577 and 1067, respectively. From the known values of the Nb and Mo K-edges at 18986 eV and 20000 eV respectively, the CCD channels are calibrated for energy. It is seen that a resolution of ~2 eV per pixel is obtained in the present setting, which agrees well with the theoretically estimated value. The EXAFS spectrum of Mo foil redrawn in calibrated energy scale, is shown in the inset of Fig. 6.

The near edge absorption (XANES) spectrum of Mo foil around the absorption edge is shown in Fig. 7 in the energy scale along with that of a MoO_3 pellet made from 99.9% pure MoO_3 powder. Fig. 7 shows a clear shift in absorption edge of MoO_3 with respect to the absorption edge of elemental Mo. The absorption spectra of the above two samples near the absorption edges have been fitted using the ATHENA code available within the IFEFFIT package. The exact edge positions at the half edge steps derived are shown in Fig. 7. The edge positions show an edge shift of ~9.34 eV between elemental Mo and MoO_3 which agrees well with the reported results implying good resolution of the present experimental set-up. Fig. 8 shows the absorption spectra of Nb foil along with that of a Nb_2O_5 pellet made from 99.99% pure powders mixed homogenously with cellulose acetate in appropriate proportion. A shift of ~ 6 eV in the absorption edges of Nb_2O_5 from that of elemental Nb is clearly visible in Fig. 8 and has also been obtained by analysis of the absorption spectra using the ATHENA code. This result also agrees well with that reported in literature. These results show the expected performance of the beamline. The beamline was commissioned in February 2008 and

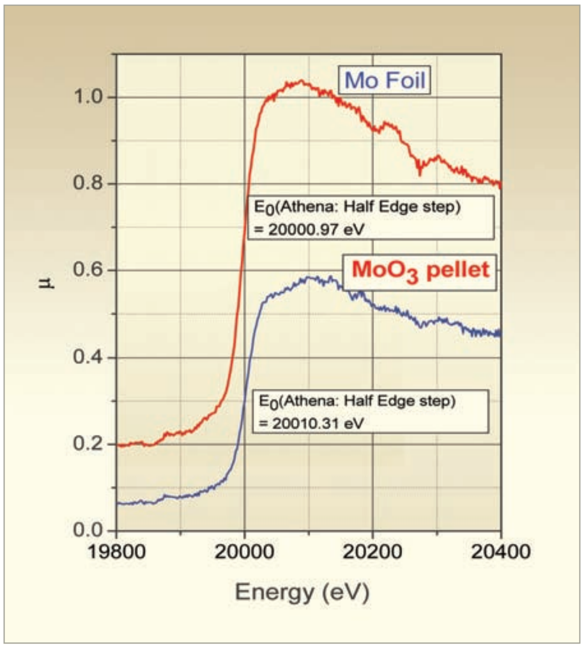

Fig.7: XANES spectra of Mo and MoO_3: the observed difference of 10 eV between the edge positions of the metal and metal oxide matches well with the reported value of 9 eV (*J. Synch. Rad.*, 6, 1999, 591)

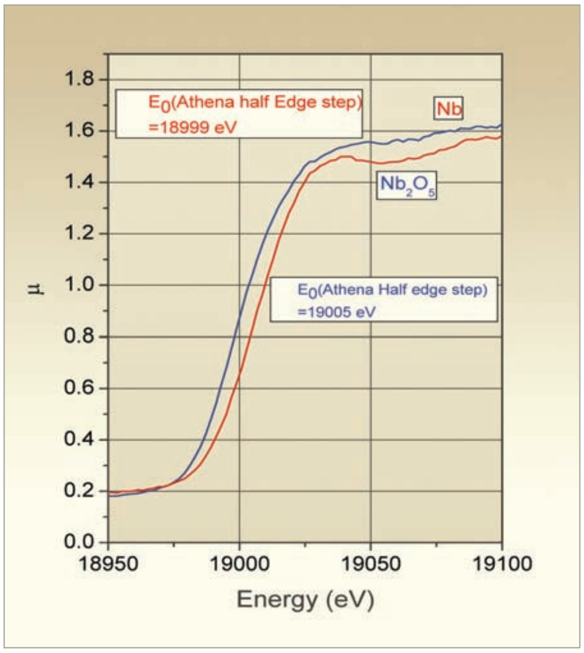

Fig. 8: XANES spectra of Nb and Nb_2O_5: The observed difference of 6 eV between the edge positions of the metal and metal oxide matches well with the reported value of 5eV (*J. Sol. St. Chem.*, 177, 2004, 1781)

since then, has been used for several EXAFS investigations on oxide crystals, U_2O_3 adsorbed kaolinite and alumina, Pt doped carbon aerogel etc. Some of the results obtained have been reported at international meets and published in refereed journals as given below:

- ·X-ray Absorption Spectroscopy of $PbMoO_4$ crystals, D. Bhattacharyya, A.K. Poswal, S.N. Jha, Sangeeta and S.C. Sabharwal, *Bull. Mater. Sci*. 2009 (in press).
- First Results from a Dispersive EXAFS Beamline at Indus-2 Synchrotron Source. Jha-S.N., Bhattacharyya D., Poswal A.K. and Sabharwal S.C., Presented at the Workshop on *Energy Dispersive X-ray Absorption Spectroscopy Scientific Opportunities and Technical Challenges*, 2-5 February 2009, Grenoble, France.
- EXAFS measurements on sorption of uranyl ions onto alumina and kaolinite at INDUS-2, RRCAT, Indore, A.K. Poswal, S.N. Jha, D. Bhattacharyya, Sumit Kumar, Aishwarya Jain, B.S. Tomar, V.K. Manchanda and S.C. Sabharwal, Presented at the Workshop on *Energy Dispersive X-ray Absorption Spectroscopy Scientific Opportunities and Technical Challenges*, 2-5 February 2009, Grenoble, France.
- EXAFS measurements on crystalline $Pb_5Ge_3O_{11}$, Ashwini K. Poswal, D. Bhattacharyya, Sangeeta, S.N. Jha and S.C. Sabharwal, Presented at the Workshop on *Energy Dispersive X-ray Absorption Spectroscopy Scientific Opportunities and Technical Challenges*, 2-5 February 2009, Grenoble, France.
- X-ray Absorption Spectroscopy of U(VI) sorbed onto Alumina, Proceeding of *Nuclear and Radiochemistry (NUCAR) Symposium*, Jan. 7-10, 2009, Mumbai, page 309, Sumit Kumar, Aishwarya Jain, B.S. Tomar, A.K. Poswal, S.N. Jha, V.K. Manchanda and S.C. Sabharwal.

Acknowledgements

The contributions of several of our colleagues at BARC namely Dr. N.C. Das for optical design; Dr. A.K. Ghosh and Mr. Vishnu Verma for heat load calculations; Mr. A.K. Sinha and Mr. V.K. Mishra for design and fabrication of the crystal bender and the experimental station are gratefully acknowledged. The authors also wish to acknowledge Mr. V.K. Raghubanshi and Mr. S.R. Kane of RRCAT for providing the front-end of the beamline, the staff of the Beam Alignment Section of IOPAD, RRCAT for their contributions in mechanical alignment of the beamline components and the staff of Health Physics Unit of RRCAT for the radiation survey work. Finally the authors wish to acknowledge the entire staff of INDUS-2 Project of RRCAT for enabling the Synchrotron beam for experiments.

Forthcoming Conference

INTERNATIONAL CONFERENCE ON PEACEFUL USES OF ATOMIC ENERGY - 2009

On the occasion of the Birth Centenary of Dr. Homi Jehangir Bhabha, the founder father of the Indian Atomic Energy Programme, the Dept. of Atomic Energy (DAE), in collaboration with IAEA and the Indian Nuclear Society is organising the above conference at Vigyan Bhavan, New Delhi from Sep. 29 to Oct. 1, 2009.

The Scientific programme of the conference will include Plenary talks, Side events and Poster Sessions and Panel/Round Table Discussions. The broad areas of deliberations could cover the main topics of 1) Nuclear Power-Challenges for Growth 2) Evolving Nuclear Technology and 3) Nuclear radiation for human welfare. Thematic topics are a) Exploration & mining of Uranium b) Small and medium size reactors c) Accelerator Driven Systems d) Waste management strategies e) Nuclear Agriculture f) Recent developments in radiotherapy and g) Materials for fusion technology and h) Fast Reactor Fuel Cycle

Important Dates:

Receipt of Abstracts of Plenary Lectures and Side Event Talks	: 10th July, 2009
Receipt of Contributed Papers	: 10th July, 2009
Intimation of Acceptance of Contributed Papers	: 1st Aug, 2009
Receipt of Full Text of Plenary Lectures and Side Event Talks	: 16th Aug, 2009
Last Date for Registration	: 16th Aug, 2009
Request for Travel support	: 10th July, 2009

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BARC NEWSLETTER

MANUFACTURING OF LARGE SIZE PIPE AND ELBOW TEST SPECIMENS FOR COMPONENT INTEGRITY TEST PROGRAMME FOR NUCLEAR POWER REACTORS

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Centre for Design and Manufacture

Introduction

The Primary Heat Transport (PHT) system is one of the most critical systems of a nuclear reactor and any failure of the PHT system would be catastrophic for the installation. As part of the studies pertaining to design / safety aspects of the piping system, of the PHT system of Indian Pressurized Heavy Water nuclear Reactors (PHWRs), varieties of Carbon Steel Pipes and Elbows of large size and Cruciform test specimens for various tests, under the Component Integrity Test Program (CITP) of RSD, are being manufactured at CDM. These test specimens made of relevant materials and of relevant geometry completely simulate the piping and other structural components of the PHT system.

A large number of these test specimens are being manufactured for experimental validation of design parameters of the PHT system of 235 & 500 MWe PHWRs under the CITP.

The task of manufacturing these test specimens, meeting the requirements of ASME Boiler & Pressure Vessel Code, Section III Class NC, was assigned to CDM, BARC. It required a lot of innovation in manufacturing and development of processes, in the making of these critical test specimens. CDM has successfully manufactured and delivered many such critical test specimens. Several other test specimens are currently under manufacture. This article reports the welding processes developed and machining techniques adopted, for meeting the desired notch configuration on the low alloy Carbon Steel Pipe and Elbow test specimens.

Description

The PHT piping system is a closed loop system. It transports the heat generated in the Reactor Vessel to the Steam Generator, by the flow of primary high pressure (70 bar) high temperature (285°C) heavy water from the Reactor Vessel to the Steam Generator and back to the Reactor vessel. The PHT system is made of Carbon Steel (ASTM A106 Grade C) pipes of sizes varying from 200 NB (120 Sch.) to 600 NB (120 Sch.). It consists of piping components like Elbows, Reducers and Tees. Manufacturing of these components all under ASME Code, Section III Class NC requirements.

Following test specimens were made, of ASTM A106/ 105 Carbon Steel piping components of sizes 200 NB, 300 NB, 400 NB, 450 NB, 500 NB & 600 NB of 120 Schedule each:

- Base Pipes Specimens
  - (a) Without any weld.
  - (b) With weld at mid-length. (Fig.1) (Type-I).
- Welded Pipe Specimens
  - (a) With welds at mid-length, and without open end Flanges (Fig.1) (Type-II).
  - (b) With welds at mid-length, and blind end Flanges. (Fig.1) (Type-III).

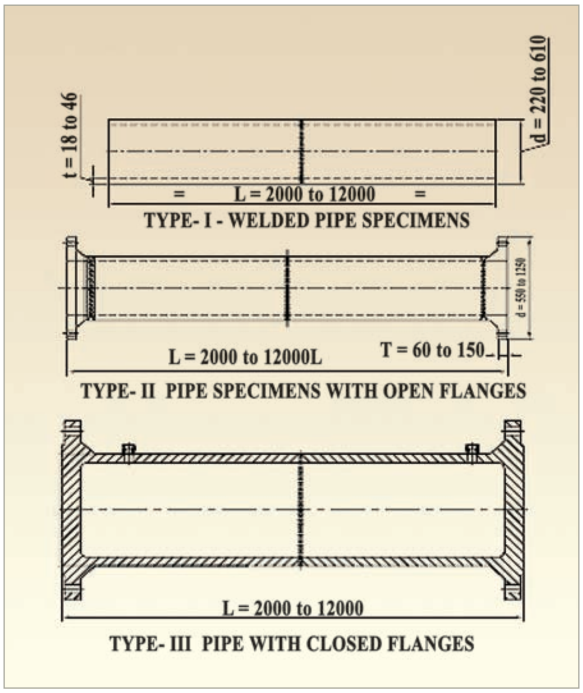

Fig.1: Welded pipe specimens

All these types of test specimens were made

(i) Without notches for base material testing,

(ii) With axial and radial notches of partial depth,

(iii) Through wall cut notches of various lengths / subtending angles at centre of section.

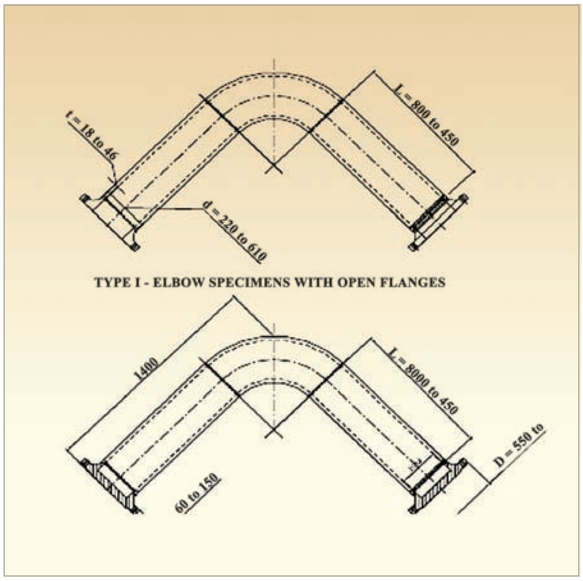

Fig. 2: Elbow test specimens

- **Elbow Specimens**, welded to pipe legs:
  - (a) With open End Flanges. (Fig. 2) (Type-I).
  - (b) With blind End Flanges (Fig. 2) (Type-II).
- **Cruciform test Specimens** of ASTM A508 Grade 5. (Fig. 3).

Fig. 3: Cruciform test specimens

These specimens were tested at SERC, Chennai by RSD, by cyclic three point load testing. In these tests, the fracture mechanics principles are applied to demonstrate, that pipes for the PHT system are unlikely to fail without prior indication of leakage. A through wall Leakage Size Crack (LSC) in the pipe was demonstrated to be stable under maximum credible loading conditions for all the piping components, namely Straight Pipes and Elbows in the entire PHT system.

Manufacturing Process Development

The PHT system pipeline manufacturing is controlled by extremely strict specifications. The PHT system components must be manufactured for high reliablity. Therefore as part of the QA (Quality Assurance) plan, each welder was ensured that he passed qualification tests, before carry out welding of the particular jobs. Every welded component then met applicable welding quality standards i.e. ASME Code, Section III, Sub section NB.

Welding process development

As these specimens were meant for design validation of the PHT system, the test specimens were also to be welded achieving the same quality levels as that of the PHT system.

Welding Process Selection: The selection of the type of welding process depended on many factors; the most important being the weld strength and a process that essentially creates defect-free welds for the given material. Factors considered included, the amount of time needed to complete the welds and the design of the joint.

The critical root pass of the weld was decided to be completed using the GTAW process and consumable A-type inserts with subsequent three stabilizing passes, were also given by the same process. AWS ER 70S-2 filler wire ensured defect-free root fusion on the critical root side of the weld. Further passes were completed using SMAW process for faster welding.

Selection of Electrode: The most important factor was to select the electrode of low hydrogen content type, to minimize susceptibility to hydrogen induced cracks, for the CS material. AWS E 7018-1 electode was selected. A detailed Welding Procedure was qualified as per ASME Code Section IX and the salient details of the qualified welding procedure are given below.

Welding Procedure Specification and Qualification Scope: Welding procedure was qualified conforming to the requirement of Section IX and Section III NB of ASME Code and as applicable for butt-welding of pipe/ fittings for thicknesses from 4.0 mm to 36.50 mm wall thickness. Weldable quality C.S plates of thickness, conforming to requirements of material listed under P1 Group 1 of Section IX of ASME Code (i.e. ASTM A105, A106, A234, A333, & A420) were used, for welding qualification. GTAW process, for root fusion and for subsequent stabilizing passes and SMAW process for the remaining passes was selected. AWS A- type inserts for fit up, ER 70S-2 filler wires for stabilizing passes by GTAW process and E 7018-1 Electrodes for remaining passes by SMAW process were selected.

Edge Preparation of Base Metal: All butt welds have ends prepared as shown in Fig. 4. All flame cut edges were machined.

Cleaning and Fit up: Cleaning was carried out for the edge prepared parts (prior to fit up for welding), consumable insert and filler wire thoroughly by approved solvents and these were DP tested for detection and segregation of inherent material defects, if any.

Welding Techniques: Wherever possible, job was positioned for down-hand (1G position) welding. This allowed quicker completion of the job and at lower cost. The same technique for each layer was used, to avoid severe quenching.

Preheating and Interpass temperature maintenance: The joint was preheated to a temperature of 120±10°C and maintained till the completion of the weld. Preheating at the time of tack-welding of the joint was also necessary.

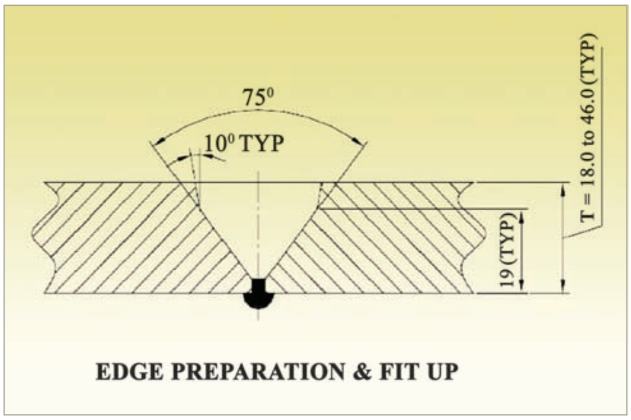

Fig. 4 Edge preparation and fit up

Inter-pass Cleaning: All traces of slag and flux were removed by means of wire brushes, so that successive beads or layers are not deposited.

Post Weld Heat Treatment: The weld joints were post-weld heat-treated, for stress relieving at a temperature range of 595°C to 675°C, for the Pipe and Elbow specimens. A repeated heating and cooling cyclic process at a temperature range of 450°C to 600°C spanning over 72 hrs was used, for the Cruciform test specimens.

Repairs of welds: Any weld repair was subject to the approval of QA Engineer. Any defect that appeared in the weld was removed by grinding. Inspection was carried out to check, that the defect was completely removed prior to re-welding on those areas. Weld repairs were made by a qualified Welder using the proper procedures.

Weld Identification: Each weld was identified with a weld joint number, line number and Welder's symbol by permanent marking.

Inspection: All the welds were inspected and examined as per the QC plan given in Table 1 and according to the appropriate stage and the level of examination.

Additional Impact Test: Impact test were carried out additionally as per ASME Code, NB 4300 of Section III, for WPS qualification.

Table 1: QC Plan / Inspection Stages

Welding Stage	Inspection required	Legends
Edge preparation	S+D	**S**-100% Supplementary - DPT / MPT **D**- Dimensional Inspection **V**- 100% visual **R**- 100% radiography
Cleaning / Fit up	V+S+D	
Root pass	V+S	
After Stabilizing passes	V+S+R	
After First 3 layers	V+S	
After Final layer	V+S+R+D	

Welder Qualification: All the welders employed for the job were qualified for the process as per ASME Code Section IX requirement.

Heat-treatment

Heat treatment is an important operation in achieving the requisite quality for many of the engineering components. Only by heat treatment, it is possible to improve / maintain good mechanical properties of the fabricated steel components. For fabricated jobs, heat-treatment not only means improvement of mechanical properties by some heating and cooling operation, but it is much more than that. It is a well known fact that hydrogen-induced cracks require a hard microstructure which is created by a hardenable material and subjected to fast cooling from 800°C to 500°C. The cooling of welded parts can be slowed down; thereby these cracks can be prevented by:

- Applying preheat,
- Maintaining the required inter-pass temperature,
- Increasing welding power and reducing welding linear travel speed.

Pre-heating: Pre-heating was included in the process for these Carbon Steel test specimens, to reduce the risk of hydrogen cracking, to reduce the hardness of the weld heat-affected zone of welds, to reduce shrinkage stresses during cooling, to improve the distribution of residual stresses, to lessen distortion and to avoid thermal shock for acquiring good quality welds.

The preheating temperature selected was 120±10°C, based on the Carbon and alloy content of the base metal and the combined thickness (for a butt weld - combined thickness is twice the thickness of the parent material and for a T fillet weld three times the thickness). This temperature was maintained till the completion of the weld.

Also, care was taken, to avoid improper heating, as it would adversely affect the weld by making it hard and brittle or by making it more prone to oxidation and scaling. When preheating was locally applied, it was extended to at least 75 mm distance from the weld location and the distance was measured on the opposite face to the one being welded.

Fig. 5: 600 NB Elbow with Induction heating system

Inter-pass temperature: It is known, that one reason for the yield strength of a weld exhibiting a considerable variation (in the range of 700-950 MPa for the same consumable electrode) is that, the cooling curve of the weld is closer to the limit of hardenability of the material. This means that the microstructure obtained becomes sensitive to the variations in the interpass temperature, in multi-run welds.

Hence it was also decided to have a scheme for inter-pass temperature maintenance for the higher sized specimens i.e. from 400 NB & above sizes. While multi-pass welding was being done, the temperature of base metal was never allowed to rise above 200°C and the time between the two weld passes was monitored to keep this under check.

Post weld heating: It is known that high-level of residual stresses can occur in weldments, due to restraint by the parent metals during weld solidification. The removal of residual stresses was of primary importance for these jobs, as it was meant to combat failure due to mechanical or thermal overloading, brittle fracture conditions at low temperatures, corrosion, cracking or distortion. Hence, it was decided to opt for a post-weld thermal stress relief, to remove the residual stresses resulting from welding.

Residual stresses can be reduced after a welding process, by Post Weld Heat Treatment. The joined parts are maintained at a temperature consistent with the hot weld at its highest expansion level, the whole joint then cools off at the same rate, thus reducing residual stresses.

Pre-heating Techniques: Time taken for Pre-heating, constitutes a considerable portion of the total welding cycle time. Effective utilization of the heat sources and proper arrangement for preheating of welds can save time.

a) Flame Heating: For lower sizes, up to 300 NB, LPG gas flame heating was preferred as the mass effect on heating time was not significant.

b) Induction heating: Induction heating was selected for higher sizes, from 400 NB to 600 NB sizes, as it is a well known method of providing fast, consistent heat for manufacturing applications for metals or other electrically conductive materials. The process relies on induced electrical currents within the material which produces the resistive heat. This has made pre-heating a remarkably simple, cost-effective heating method and reduced cycle time considerably for higher sizes. Fig. 5 shows the induction heating system being used on a 600 NB Elbow.

There are certain limits to the flexibility of the induction heating process - mainly arising from the need to manufacture dedicated inductors for the variety of applications. This is quite expensive and requires the marshalling of high current-densities in small Copper inductors and which can require specially engineered"Copper-fittings".

Post-weld heat-treatment technique: Correct stress relieving demands a pre-calculated controlled rate of heat rise, optimum temperature soak period and cooling rate which varies according to the metal composition, the volume/ mass of the work piece and so on. Based on these factors, it was decided to have the weld joints post weld heat treated for stress relieving at a temperature range of 595°C to 675°C for the Pipe and Elbow specimens. A repeated heating and cooling cyclic process, at a temperature range of 450°C to 600°C spanning over 72 hrs for the Cruciform test specimens, was adopted.

The thermocouples were directly tacked into the joint but encased in a 6.4 mm diameter tube, approximately 20 mm long (flattened to grip the thermocouple leads) and the tube was tack welded to the base metal. The width of the heated band on each side of the greatest width of the finished weld was kept not less than twice the wall thickness of the thicker component. Uniform temperature around the entire circumference of the piping was ensured. The cooling rate of the pipe on each side of the heating device was controlled, to provide a gradually reducing temperature away from the heated band during the entire post-weld heat treatment. Open ends of pipe lines were plugged to prevent uncontrolled convention heat losses. Among the various methods of stress for the Pipe and Elbow specimens, electrical furnace method was of course the first choice for stress relieving. Quite obviously it was not possible to take work pieces of very large sizes to a furnace or vice versa. In such cases, localized stress relieving using resistance heating elements around the welds of the work piece, were used with suitable insulation pads as it was versatile and more manageable from all aspects of set up and handling. Fig. 6 shows the furnace specially designed and developed at CDM, for stress relieving of the Cruciform specimens.

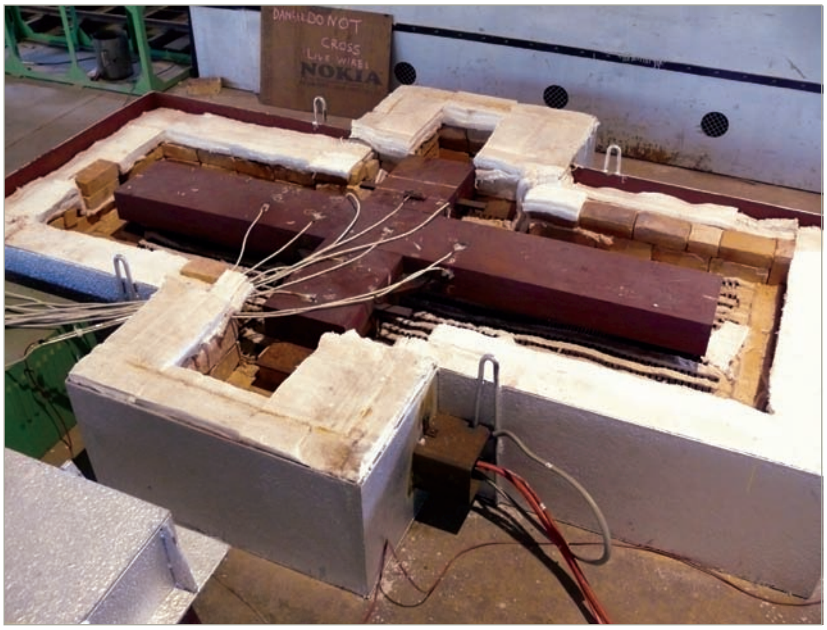

Fig. 6: Cruciform specimens, being set in the custom built furnace (lid open) for Stress relieving

QA plan for Welded test specimens

The most common welding defects found for this type of Carbon Steel welds are Porosity, Lack of root fusion and Poor penetration, Hydrogen cracking, Slag inclusion and Undercutting. For ensuring consistent quality of welds, following quality checkpoints were devised and maintained as per the QA plan shown in Table 1. To minimize the chances of occurrence of these welding defects, it was ensured that the welding was done in accordance with the Welding Procedure, especially the travel speed of the pass, the electrode quality, size and type, purging / shielding gas supply and welding machine settings.

Machining of Notches

Two types of notches were machined as indicated in Figs. 7 and 8.

V-type Notches of partial depth

V-Notch tip angle was 90° and notch tip radius was 0.1 mm maximum. The width of notch was 3.0 mm max. and depth varied from 10 to 50 % of the wall thickness. For the Pipes, circular notches were located at the longitudinal centre of pipe on base material or welds. For Elbows (axial / circular) notches were located at longitudinal centre on extrados, intrados or along the axis (Fig. 7).

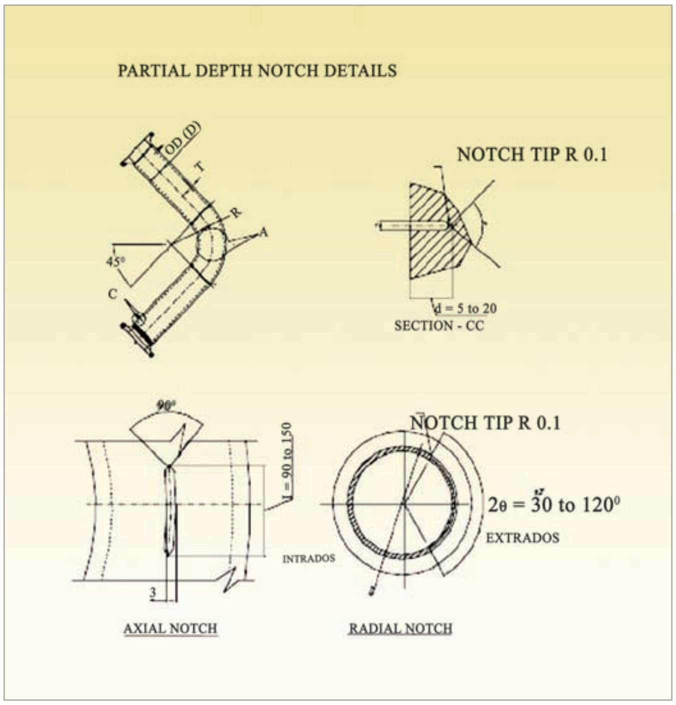

Fig. 7: Partial depth type notches

Through wall-cut V-notches, with ends having a radial profile

The notches were with 90° notch tip angle and tip radius 0.1mm R max. Notch width was 3.0 mm max. These Notches were of various lengths / subtending angles at centre of sections. For the pipes, notches were located at the longitudinal centre of pipe on base material or on welds. For Elbows, notches were located at longitudinal centre (axially / circularly) at extrados / intrados. (Fig. 8).

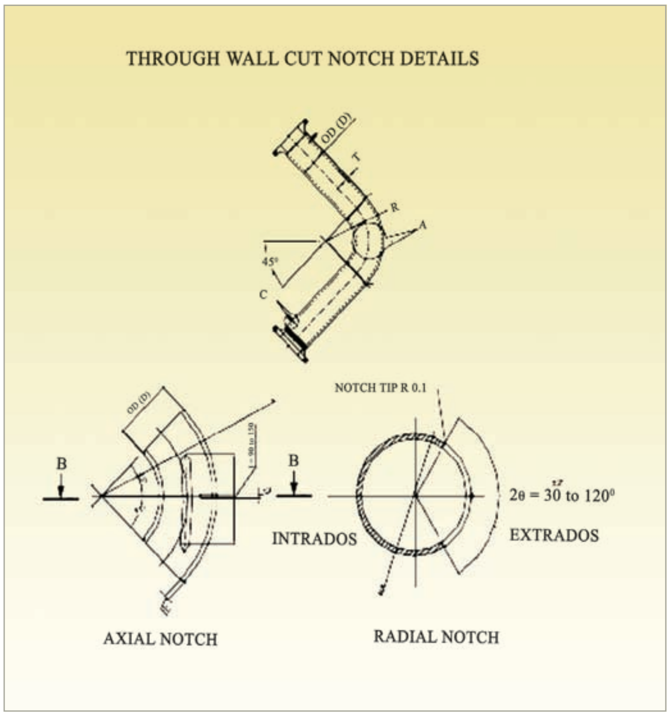

Fig. 8: Through wall cut type notches

Selection of Machining process for V-Notches: Process for machining of these notches was selected, based on the size, location and geometry of the notch and size of specimen.

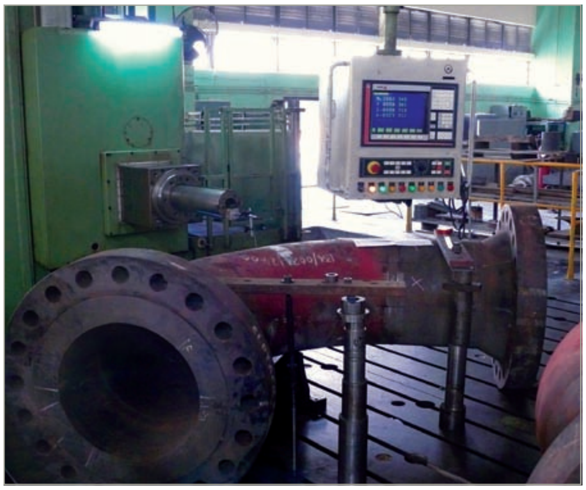

Fig. 9: CNC machining of notches on 600 NB Elbow specimens

Fig.10: EDM machining of notches on 500 NB Elbow specimen

CNC machining by circular interpolation using single point form tool (fly cutter) and machining using circular saw V-form cutter were found to be faster methods for notch machining. A V-shaped electrode of the same shape as that of the V-notch, using the EDM machining process was adopted, where accessibility to machine the V-profile was a problem. For specimens up to 200 NB, EDM machining method was preferred as compared to CNC machining, as it could be easily accommodated within the EDM machining tank. For machining of through wall cut notches both EDM & CNC processes were adopted – CNC for cutting the notches through the wall & EDM process for achieving the profile of the notch ends.

EDM Machining of V-notches: Electrical Discharge Machining (EDM) employing the notch-profiled electrode was used, to machine the desired shape of V-notch on a work piece under carefully controlled conditions. EDM offers following advantages over conventional, "chip-making" machining methods:

- Ability to machine extremely narrow notches.
- Ability to hold very close dimensional tolerances.
- Ability to machine irregular profile shapes not otherwise possible.
- Ability to access hard-to-reach locations such as Elbow intrados.

The limitation of EDM in obtaining very sharp notches was overcome, by using an exclusive finishing electrode for each V-notch for the final cut. Thus, it was possible to get the final notch tip radius of 0.1 mm R.

Conclusion

The successful fabrication and machining of the notches on these critical LBBA test specimens could be completed as per the strict requirements of ASME code with consistent good quality welds and with minimum repairs by systematic planning and development of processes. Many of these specimens have been successfully tested as well.

Additional Reading

1. AWS Hand book on Welding.
2. ASME Section IX, Qualification Standards for Welding & Brazing.
3. ASME Section III, Division NB – Rules for Construction of Nuclear Core components.

"NON-HERMITIAN HAMILTONIANS IN QUANTUM PHYSICS": REPORT ON THE DAE-BRNS INTERNATIONAL CONFERENCE

The Homi Bhabha Centenary Conference on "Non-Hermitian Hamiltonians in Quantum Physics" was organized by the Nuclear Physics Division during January 13-16, 2009, at the Multipurpose Hall, BARC, Anushakti Nagar, Mumbai. The Conference was supported by the Board of Research in Nuclear Sciences and the Tata Institute of Fundamental Research, Mumbai. The conference brought together some of the best-known people on the subject from all over the world, with an impressive representation of institutions and universities from eleven states of India. The conference was inaugurated by Sir Michael Berry, University of Bristol, UK, on January 13, 2009. The inaugural session was presided by Dr. Srikumar Banerjee, Director, BARC. The inaugural lecture by Sir Michael Berry on "Boundary conditions that vary" set the tone and spirit of the conference with a beautiful presentation of a new idea, full of exciting new results. In his welcome address, Dr. Banerjee traced the history of quantum mechanics and pointed out that the present ideas could be forerunners to new revolution in quantum mechanics, not only from a basic point of view, but also perhaps leading to new developments in quantum computing or communication. This view was endorsed in a press release by Prof. Carl Bender of the University of Washington (and also one of the originators of the new concept of PT-symmetry). Dr. R.K. Choudhury, Chairman of the conference & Head, NPD and Dr. Sudhir R. Jain, convenor (who also introduced random matrix theory and exactly solvable models to the theme of the Conference a few years ago), seconded Prof. Bender's view.

About ten years ago, a possible generalization of quantum mechanics, which incorporates non-Hermitian Hamiltonians was proposed by Prof.Carl Bender and co-workers. This led to a large flurry of research on PT-symmetric quantum mechanics and quantum field theory. The physical systems that violate parity and time-reversal symmetry belong to this class - they may range from two dimensional statistical mechanics, quantum chromodynamics, nuclei with shapes belonging to PT classification and their peculiar properties, relaxation of well-known systems like two-dimensional Ising model and so on. To bring all the active people together, Miloslav Znojil (Nuclear Physics Institute, Academy of Sciences, Rez, Czech Republic) commenced a series of meetings in 2003. The first

Dr. S. Banerjee speaking at the inaugural function. On the dais Prof. Sir Michael Berry and Dr. R.K. Chodhury can also be seen.

two meetings were held in Prague, the subsequent meetings were held in Istanbul, Turkey (2005), Stellenbosch, South Africa (2005), Bologna, Italy (2006), London, U.K. (2007), and Benasque, Spain (June 2008). The conference held in BARC was the eighth in the series. During these meetings, a number of new results were announced. The papers submitted were published in prestigious International journals after standard refereeing process (*Czech Journal of Physics, Journal of Physics A: Mathematical and Theoretical, Symmetry, Integrability and Geometry: Methods and Applications*). The papers presented during this conference will appear as a Special Issue of *Pramana-Journal of Physics*, published by the Indian Academy of Sciences and Springer-Verlag.

The Conference was preceded by a day of Orientation Course, with beautiful pedagogical lectures by Professors Michael Berry, Martin Sieber, Kirone Mallick, and Roberto Tateo. The programme of the conference was conducted in such a manner that different sub-fields were bunched together. Following were the main topics: (T1) PT-symmetry and pseudo-Hermiticity; (T2) Open quantum systems; (T3) Non-equilibrium statistical mechanics and (T4) Random matrix and field-theoretic models and quantum computation.

On the first topic, comprehensive reviews were presented in the three keynote lectures by Carl Bender (USA), Frederick Scholtz (South Africa) and Avinash Khare (India). Time-dependent generalizations of the concept of pseudo-Hermiticity and new results on related scattering problems were presented by Miloslav Znojil (Czech Republic), Geza Levai (Hungary) and Hynek Bila (Czech Republic). Various PT-symmetric models and their rigorous mathematical results on the nature of eigenvalues (energy levels) were presented by Ali Mostafazadeh (Turkey), E. Caliceti (Italy), Andreas Fring (UK), Zafar Ahmed (India), Milos Tater (Czech Republic), Petr Siegl (Czech Republic), S.C. Mishra (India) and B.P. Mandal (India). Nonlinear evolution equations and supersymmetry were studied by C. Nagaraja Kumar (India) and Barnali Chakrabarti (India).

The field of Open Quantum Systems (T2) was reviewed from various angles – Marek Ploszajczak (France) presented shell model of nuclei in the complex energy plane, whereas Ingrid Rotter (Germany) explained the role of Non-Hermitian Hamiltonian in inelastic scattering and Abhishek Dhar (India) presented beautiful results on electron scattering from an interacting region. The subject has witnessed important advances on the classic problem of understanding and expressing precisely the resonance eigenfunctions. Whereas the rigorous result on density of resonances was presented by Sudhir R. Jain (Convener) in 2005, the statistics of resonances for disordered systems was presented by Joshua Feinberg (Israel) during this conference. The only analytically exact results on resonance eigenfunctions were reported by Martin Sieber (UK). Exciting developments on resonances and non-Hermiticity were shown by Naomichi Hatano (Japan).

The session focusing on (T3) was conducted at the Tata Institute of Fundamental Research, Mumbai. Deepak Dhar (India) discussed an exciting problem related to sandpile models with stochastic toppling rules and obtained results on steady-state density profile. Gert-Ludwig Ingold (Germany) presented exact basic results on specific heat of open systems. Mustansir Barma (India) presented the connection of steady-state behaviour of non-equilibrium problems with non-Hermitian Hamiltonians while he presented a PT-symmetric random walk problem with fluctuating bias. Henk van Beijeren (Netherlands) presented his famous work on the connection of microscopic reversibility and transport phenomena, particularly the Green-Kubo formulae. Kavita Jain (India) showed exact phase diagram of quasi-species model with mutation rate modifier. Bishwajyoti Dey (India) has done extensive work on discrete breathers, here he presented quantization of these modes for Fermi-Pasta-Ulam lattice with non-uniform geometry. Non-Hermitian Bose-Hubbard dimmer has been studied by the group

A section of the delegates at the end of the Concluding Session

of Hans-Juergen Korsch at Kaiserslautern, Germany, some of the new exciting results were shown by Eva-Maria Graefe (Germany). Studies of parity and time-reversal violations in heavy polar molecules have been studied by Malay Nayak (India), who presented a summary of this work.

Random matrix theory with random interactions was reviewed by V.K.B. Kota (India). Random matrix theory was also employed to study various kinds of problems: Nivedita Deo (India) studied RNA with external interactions; new universal long-time tails in correlation functions for systems that violate parity and time-reversal invariance were shown by Sudhir R. Jain (India). Pragya Shukla (India) presented universal results for non-Hermitian systems and Vinayak (India) showed a new method of making a transition from Poisson to Circular ensemble. Among others, exceptional points in classical and quantum mechanics were particularly reported on by Andrei Smilga (France) and Ali Mostafazadeh (Turkey). The connection of the Faddeev-Reshetikhin model and PT symmetry was explained in the talk by Ashok Das (USA). The nature of perturbation series and Landau pole in quantum electrodynamics was presented in the talk by Mofazzal Azam (India). In a session devoted to quantum computation, R. Simon (India) ignited our imagination by his masterly explanation of the structure of states and maps in quantum mechanics, posing several elementary, open and important problems. Arul Lakshminarayan (India) presented new results on the generation of multipartite entanglement due to avoided crossings. Related to multipartite entanglement, Prasantha Panigrahi (India) talked on teleportation, quantum information splitting and dense coding. The final talk of the conference by Arun Pati (India) announced new results on entanglement in non-Hermitian quantum theory.

It was decided that the next two conferences in the series would be organized in China and Germany.

NATIONAL SYMPOSIUM ON SCIENCE AND TECHNOLOGY OF GLASS AND GLASS-CERAMICS (NSGC-08): A REPORT

A National Symposium on Science & Technology of Glasses / Glass-ceramics (NSGC-08) with special emphasis on applications in laser, radioactive waste management, optical communication, biomaterials and sealing, was held during Oct. 15-17, 2008, at the Multipurpose Hall, Training School Hostel, Anushaktinagar, Mumbai under the aegis of the Materials Research Society of India (MRSI) Mumbai-Chapter, in association with BARC and the Central Glass & Ceramic Research Institute (CGCRI) Kolkata. Dr Anil Kakodkar, Chairman Atomic Energy Commission and Secretary Department of Atomic Energy, inaugurated the symposium. In his inaugural address, Dr Kakodkar appreciated the idea of organizing a biannual symposium. The previous one was held during 2006, which had a direct relevance to DAE programme. He briefly mentioned about the growth of glass and ceramics activities in DAE and stressed on the development of suitable matrices for containment of radioactive wastes. He also released the proceedings of the symposium. Prior to this, Dr. S. Banerjee, Director, BARC, welcomed the delegates and invited speakers. Dr. Banerjee, in his address, discussed some basic concepts in glass science and brought out the growth of glass and ceramics technology in the country, in general and in BARC in particular. Dr. G.P. Kothiyal, Convener NSGC-08 and Secretary MRSI Mumbai Chapter, presented a brief account of the activities of MRSI, Mumbai Chapter and gave an introduction to NSGC-08.

On this occasion, Dr H.S. Maiti, Director, CGCRI, Kolkata released the souvenir in the inaugural session and also delivered an evening talk on New Functional Glasses and Glass-Ceramics. Prof. Ajit Kulkarni, IIT / Mumbai and Co –Convener NSGC-08, proposed the vote of thanks.

Following aspects of glasses and glass-ceramics were discussed:

- Physics / Chemistry and Engineering
- Laser applications-materials, properties, devices
- Radiation resistance shielding /optics
- Radioactive waste management-materials, properties, long term behaviour
- Encapsulation / sealing – materials, properties, interface behaviour
- Biomedical and energy related applications
- Space applications
- Glass fibers and applications
- Synthesis / production- techniques, new methods issues

Dr. Anil Kakodkar (Centre), Chairman, Atomic Energy Commission and Secretary DAE, releasing the Proceedings of NSGC-08. Others from left to right are: Prof. A. K. Kulkarni, Dr. H. S. Maiti, Dr. S. Banerjee and Dr. G. P. Kothiyal

- Devices and related instrumentation
- Industrial perspective in the Indian context

There were seven sessions including the Inaugural and Concluding Sessions in this two and half day symposium. 220 delegates from various National Institutions / Universities / Colleges and industrial houses, of which 52 were research scholars, participated in the symposium. A special mention can be made of the participation of Dr. Paul Danielson, M/s Corning Inc. USA, Prof. Lionel Montagne, University of Science & Technology of Lille, France. Young researchers were encouraged by way of giving them travel support and local hospitality. Proceedings of the symposium containing contributed papers and invited talks, was brought out on this occasion. A total of 14 invited talks were delivered on various aspects of glasses and glass-ceramics by eminent scientists from various institutions like BARC, DRDO, ISRO, CGCRI, IACS, BHU, IITs, Universities, Industries etc. from India and abroad. In addition to this, 85 contributed papers were presented as posters. The following four posters were selected as the Best Posters for awards under the following four different categories.

1. **Glass and Glass-Ceramics for Laser and Optical applications**

A view of the delegates and invitees at the Inaugural Function

Remarkable red luminescence upconversion in Er^{3+} doped novel low phonon antimony glasses, Tirtha Som and Basudeb Karmakar, Central Glass and Ceramic Research Institute, Kolkata.

2. **Glass & Glass - Ceramic Synthesis and Characterization**

   In-vitro dissolution studies of machinable glass ceramics for Dental implant in Artificial Saliva and Mouse fibroblast (L929), Atiar Rahaman Molla, Bikramjit Basu, IIT Kanpur, Kanpur Glass Division, Central Glass and Ceramic Research Institute, Kolkata.

3. **Glass & Glass-Ceramics for Devices and Instrumentation**

   Role of in-house developed ceramics-to-metal seals in indigenous linac technology, C.S. Nainwad, S.A. Chawre, Subhadra K., N. Nayek, M. Kandpal and S. Das, SAMEER, Mumbai.

4. **Glass & Glass-Ceramic for Radiation Shielding & Radioactive Waste**

   Studies on glass matrix for the immobilization of high level waste generated at the Kalpakkam reprocessing plant, K. Shivakamy, A.G. Shanmugamani, R. Lekshmi, S.V.S. Rao, P.K. Sinha and C.P. Kaushik, BARCF, Kalpakkam, WMD, BARC.

Prof. L. Montagne presented the poster awards and the Secretary, Mr. V. K. Shrikhande, proposed the vote of thanks.

The symposium was supported by DAE- BRNS, DST, ISRO, DRDO and CSIR.

NATIONAL WORKSHOP ON GLASS-TO-METAL AND CERAMICS-TO-METAL SEALS (NWGCS): A REPORT

A National Workshop on Glass-to-Metal & Ceramics-to-Metal Seals (NWGCS) was held during Oct. 13-15, 2008 at BARC, Mumbai under the aegis of Materials Research Society of India (MRSI) Mumbai-Chapter, in association with BARC and the Indian Society of Scientific Glass blowers (ISSG) Mumbai Chapter. Dr. S. Banerjee, Director, BARC, inaugurated the Workshop. He highlighted some important facts about glass science and its growth. Mr. S. Dasgupta, Senior General Manager, Scientific & Industrial Products, M/s. Borosil, Mumbai delivered the key note address and brought out the role of M/s. Borosil in the development of technology in the glass industry in India. Prior to the inauguration, Dr. A.K. Suri, Director, Materials Group, BARC welcomed the guests, invitees and participants of the Workshop. Dr. G.P. Kothiyal, the Convener NWGCS and Secretary MRSI Mumbai Chapter, briefed about the background in organizing this Workshop. Mr. S.M. Shafi, Chairman, ISSG-Mumbai Chapter, briefly mentioned about the activities of ISSG, particularly of the Mumbai-Chapter and proposed the vote of thanks.

Experts in glass science and technology from BARC, TBRL, Chandigarh, SAMEER and M/s. Jelosil, Switzerland delivered talks on the following topics;

Dr. S. Banerjee (Centre), Director, BARC releasing the lecture notes of NWGCS. Others from left to right are: Mr. S.M. Shafi, Dr. A. K. Suri, Dr. S. Dasgupta and Dr. G.P. Kothiyal

A view of the delegates and invitees at the Inaugural Function

1. Glass – an engineered material with diversified technological applications
2. Fabrication process in glass-to –metal seal
3. Ceramic-to-metal seal: an overview
4. Ceramic- to- metal seals
5. Active metal brazing for ceramic-metal hermetic joining
6. Fabrication of pinch seal
7. Glass / ceramic - to - metal seals: inspection and testing
8. Industrial safety aspects pertaining to glass blowing operations.

A total of 52 participants from BARC, IGCAR Kalpakkam, Heavy Water Board, ECIL, Hyderabad, Indian Institute of Science, ISRO DRDO labs, NCL, Pune, IIT, Mumbai including industries like BEL Pune, attended the Workshop. An eminent glass technologist from M/s. Jelosil, Switzerland delivered an invited talk and actively participated in the demonstration of the preparation of ribbon type quartz–to-Molybdenum seals. Participants were also given a specially compiled book, containing the lecture notes on the above topics, as study material.

A practical training and hands-on demonstration was conducted at the Glass & Ceramics Technology Laboratory (GCTL) of TPPED, for the benefit of the participants of the Workshop. Dr. S. Banerjee, Director BARC and Mr. S. Dasgupta, Senior General Manager, Borosil Glass Works visited a small exhibition arranged in the GCTL building.

A factory visit to M/s. Borosil, Mumbai was also arranged for the participants.

Dr. S. Banerjee, Director, BARC keenly viewing the Glass and Glass-ceramics exhibits and posters at the Glass-Ceramics Technology Laboratory, TPPED

53RD DAE SOLID STATE PHYSICS SYMPOSIUM (DAE-SSPS-2008) - A REPORT

The 53rd DAE Solid State Physics Symposium (SSPS-08) was jointly organized by BARC and TIFR during December 16-20, 2008 at BARC Mumbai. This annual conference is a prestigious national event, drawing overwhelming participation from researchers, from various universities across the country.

The symposium was inaugurated by Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, DAE. In his inaugural address, he emphasized on building large scale research facilities. He stressed the need to recalibrate our value system, so as to nurture an environment where young people can do their best and realize Dr. Bhabha's dream. Dr. S. Banerjee, Director BARC, delivered the welcome address and highlighted the increasing interest in condensed matter physics research. He mentioned that the availability of synchrotron source at Indus II, has opened a new phase of research in condensed matter physics. Dr. V.C. Sahni, Director RRCAT and Director, Physics Group, BARC, in his special remarks on DAE-SSPS, emphasized on Dr. Bhabha's passion for excellence and abiding faith in Indian capabilities. He pointed out that Dr. Bhabha's success in building large scale scientific institutions is a testimony to his great vision and desire to excel.

Prof. M.G.K. Menon, Dr. Vikram Sarabhai Distinguished Professor, was the Chief Guest at the inaugural session. In his address, Prof. Menon shared his reminiscences of his association with Dr. Bhabha. He reiterated Dr. Bhabha's view, that fundamental research was not a luxury, but a primary foundation which sets the standards. He described Dr. Bhabha as the pioneer of the nuclear programme in India and the greatest supporter of the space programme. In his thought provoking speech, he said that the richest legacy of Dr. Bhabha to India was the great number of trained personnel, who have embraced a vision of new India and acquired confidence in their own abilities. Prof. Menon also released the Proceeding of the DAE-SSPS-2008, which contained both invited and contributed papers. Dr. Kothiyal, Convener, DAE-SSPS 2008, highlighted the scope of the symposium and provided some statistics and trends

Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, DAE, delivering the inaugural address in solid state physics research in India. He acknowledged the overwhelming response received from the participants.The inaugural session concluded with a formal vote of thanks by Dr. A.K. Rajarajan, Secretary, DAE -SSPS 2008.

The scientific programme of the symposium comprised of about 625 presentations on wide ranging subjects such as

- Phase Transitions
- Soft Condensed Matter including Biological Systems & Liquid Crystals
- Nano-materials
- Experimental Techniques & Devices
- Liquids, Glasses & Amorphous Systems
- Surfaces, Interfaces & Thin Films
- Electronic Structure & Phonons
- Superconductivity
- Transport Properties
- Semiconductor Physics
- Magnetism including Spintronics
- Novel Materials and Nano-materials.

The 625 presentations included 23 invited talks by eminent speakers from both India as well as from overseas labs, 27 theses, 558 posters and 14 oral presentations. The sessions on December 17, 2008 were dedicated to the memory of Dr. K.R. Rao, Former Director, Solid State and Spectroscopy Group, BARC. Dr. L. Madhav Rao, ex-BARC, Prof. R.K. Singh, MATS University, Raipur and Dr. S.L. Chaplot, Head, Solid State Physics Division, BARC, spoke on their reminiscences about him. Rich tributes were also paid to him by various speakers during the course of their talks.

A glance at the content of the papers revealed, that the number of papers in the category of nano-materials was the largest, closely followed by papers on thin films, magnetism, which also covered a significant number of nanomaterials. In magnetism, topics like magneto-caloric effect and spintronics materials and in amorphous and glassy materials topics such as optical and transport properties were seen to be popular. Significant contributions were also made in semiconductors and biological materials.

There were nine sessions of invited talks by eminent speakers covering a wide spectrum of topics related to solid state physics. The studies of condensed matter at high pressures were excellently covered by Prof. Karl Syassen from the Max-Planck-Institut für Festkörperforschung, Germany and Dr. N.V. Chandrashekhar from IGCAR, Kalpakkam. Important lectures on various aspects of magnetism were delivered by Dr. A. Sundaresan from JNCASR, Bengaluru, Dr. Kaustubh Priolkar from the University of Goa and Dr. Amitabh Das from BARC. Prof. A.G.U. Perera from Georgia State University, USA covered the topic of UV to IR dual and Triple Band detectors, operating at or around room temperature. Prof. Hema Ramachandran from RRI, Bengaluru spoke on Light scattering in random media. The lectures on molecular electronics were delivered by Dr. S.K. Gupta from BARC and Dr. Swapan Pati from JNCASR, Bangaluru. Dr. Stefan Adams from the National Univ. of Singapore talked about ion transport pathways in glasses, as studied by experimental and computational methods. Prof. P.B. Sunil Kumar of IIT Chennai delivered a lecture on collapse dynamics of an anchored polyelectrolyte. The topic of thin films and multilayers was covered by Prof. Ajay Gupta from IUC Indore and Dr. Saibal Basu from BARC. Prof. Satish Ogale from NCL Pune, delivered a lecture on functional nanomaterials. Prof. G. Baskaran from IMSc, Chennai spoke on the physics of graphene and Dr. Shankar Ghosh from TIFR talked about Microrheology of a sticking transition. Dr. Abhay Pashupati from Princeton University, USA presented the latest results on high Tc superconductors using atomic resolution STM measurements on Bi-2212. A half day session during the symposium, was devoted to the Young Achiever award and thesis presentations which were judged by a panel of jury for awards.

Chief Guest Prof. M.G.K. Menon, Dr. Vikram Sarabhai Distinguished Professor, sharing his reminiscences of his association with Dr. Bhabha, in the inaugural session.

In addition to the invited talks, two interesting evening lectures were delivered– one by Prof. Amitava Raychaudhuri, Director, HRI, Allahabad on the "Large Hadron Collider at CERN and its Physics Implications", and the second by Prof. P. Ramachandra Rao, Raja Ramanna Fellow, ARCI, Hyderabad on "Natural Materials Synthesis".

Commemorating the birth centenary year of Dr. Homi J. Bhabha, the scientific sessions on December 18, 2008 were held at TIFR. Besides the invited talks in the morning session, there were afternoon plenary talks by Dr. V. C. Sahni, Director RRCAT, Dr. S. Banerjee, Director, BARC and Prof. Mustansir Barma, Director, TIFR, highlighting the contributions made by their respective institutions. On this occasion, all the delegates were presented the well known book entitled "Bhabha and his Magnificent Obsessions" authored by Dr. G. Venkatraman. A souvenir brought out by the Indian Physics Association covering articles / reminiscences / interviews on Dr. Bhabha, was also released. A notable feature of the symposium was the institution of a special award for two Post Graduate students, in recognition of their extraordinary contribution in M.Sc. project works in the area of Solid State Physics. Fourteen nominations from various universities across the country were received, out of which two were selected by a panel of judges, and the students were then invited to make oral presentations of their project work. All the M.Sc. project manuscripts were also included in the Proceedings.

The concluding session of the symposium was presided by Dr. V.C. Sahni, Director RRCAT and Director, Physics Group, BARC, Dr. J.V. Yakhmi, Associate Director, Physics Group, BARC and Dr. S.L. Chaplot, Head, Solid State Physics Division, BARC. The session began with the distribution of awards and certificates to Young Achiever, M.Sc. Project, Best Thesis and twenty posters. A brief summary of the symposium was delivered by Dr. Meenakshi Sunder, Secretary, DAE-SSPS 2008. Prof. R.K. Singh, Director General, Mats University and Prof. A.G.U. Perera for Georgia State University, USA shared their overall experience and impressions about the symposium. The symposium concluded with a formal vote of thanks delivered by Mr. Muniraj Singh, Local Convener DAE-SSPS-2008, who appreciated the well coordinated team work of all the members and volunteers.

भा.प.अ. केंद्र के वैज्ञानिकों को सम्मान
BARC SCIENTISTS HONOURED

श्री एस. मन्ना, श्री एस. चौधरी, श्री एस.के. सतपती एवं डॉ. (श्रीमती) एस.बी.रॉय, यूई प्रभाग को वर्ष 2007 में "इंडियन केमिकल इंजीनियर" नामक पत्रिका में प्रकाशित सर्वश्रेष्ठ शोध-पत्र हेतु कुलूर मेमोरियल पुरस्कार एवं वर्ष 2007 में पूर्वोक्त पत्रिका में ही प्रकाशित द्वितीय सर्वश्रेष्ठ शोध-पत्र हेतु एनआरसी पुरस्कार प्रदान किया गया। प्रस्तुत दोनों पुरस्कार इंडियन इंस्टिट्यूट ऑफ केमिकल इंजीनियर द्वारा वर्ष 2008 हेतु संस्थापित किये गये थे। पुरस्कार प्राप्त करने वाले दोनो शोध-पत्रों का शीर्षक "प्रडिक्शन ऑफ फाइरिंग टाइम ऑफ मेगनिशियो थर्मिक रिडक्शन (एमटीआर) रियक्शन एन्ड स्टडी ऑफ रिलेटिव इम्पोर्टन्स ऑफ दि डिपेंडन्ट पेरामीटर्स यूज़िन्ग आर्टिफिशल न्यूरल नंटवर्क" है।

Mr. S. Manna, Mr. S. Chowdhury, Mr. S.K. Satpati and Dr. (Ms.) S.B. Roy of UED have received the Kuloor Memorial Award for the Best Technical Paper published in the Journal "Indian Chemical Engineer" in 2007 and also the NRC Award, 2nd Best Paper published in the same journal in 2007. These awards were instituted by the Indian Institute of Chemical Engineers, for the year 2008. The title of their paper, which received both the awards is "Prediction of Firing Time of Magnesio Thermic Reduction (MTR) Reaction and study of relative importance of the dependent parameters using Artificial Neural Network".


Mr. S. Manna

श्री एस. मन्ना, यूरेनियम निष्कर्षण प्रभाग ने हल्दिया इन्सटिट्यूट ऑफ टेक्नॉलोजी से केमिकल इंजीनियरिंग में बी.टेक तथा आइआइटी खरगपुर से केमिकल इंजीनियरिंग में एम.टेक प्राप्त किया। इन्होंने डीजीएफएस 02 बैच से भाभा परमाणु अनुसंधान केंद्र में कार्यारंभ किया तथा प्रशिक्षण विद्यालय में ऑरियंटेशन कोर्स के दौरान केमिकल इंजीनियरिंग में प्रथम स्थान प्राप्त किया। आप फलौराइड एफलोयंट ट्रीटमेंट प्लान्ट परियोजना एवं नाइट्रेट एफलोयंट ट्रीटमेंट प्लान्ट परियोजना में कार्यरत थे। विभिन्न विकासमूलक अध्ययनों की सहायता से आपने इस प्रक्रिया की उन्नति हेतु परिश्रम किया । अंतर्राष्ट्रीय एवं राष्ट्रीय सम्मेलनो/ पत्रिकाओं में पांच शोध-पत्र आपके श्रेय में हैं।

Mr. S. Manna of Uranium Extraction Division, obtained B. Tech in Chemical Engineering from the Haldia Institute of Technology and M. Tech in Chemical Engineering from IIT Kharagpur. He joined BARC through DGFS 02 batch and was ranked 1st in Chemical Engineering, during orientation course in training school. He has involved in Fluoride Effluent Treatment Plant project and Nitrate Effluent Treatment Plant project. He has been associated with different developmental studies for betterment of the process. He has 5 National and International Conference/ Journal papers to his credit.


Mr. S Chowdhury

श्री एस. चौधरी ने वर्ष 1994 में बंगाल इंजीनियरिंग कॉलेज, कलकत्ता युनिवर्सिटी से (धातुकी) बी.ई की शिक्षा प्राप्त की और एम.टेक हेतु आइ-आइटी बीएचयू में स्थानांतरन किया। तत्पश्चात इन्होंने वर्ष 1995 में भाभा परमाणु अनुसंधान केंद्र के प्रशिक्षण विद्यालय के 39वें बैच में कार्यारंभ किया। वर्ष 1996 से यूरेनियम धात्विक उत्पादन तथा सहायक विकास-संबंधी गतिविधियों में व्यस्त हैं। वर्ष 2002 मे आपने एम.टेक की शिक्षा प्राप्त की। सम्मेलन / पत्रिकाओं में कई शोध-पत्र आपके श्रेय में हैं।

Mr. S. Chowdhury obtained his B.E. (Metallurgy) from Bengal Engineering College, Calcutta University in 1994 and thereafter moved to IT-BHU for M Tech.

Subsequently, he joined BARC training school (39th batch) in 1995. He is engaged in uranium metal production and associated developmental activities since 1996. He obtained his M. Tech degree in the year 2002. He has few journal and conference papers to his credit.

Mr. S. K. Satpati

श्री एस.के सतपति, यूरेनियम निष्कर्षण प्रभाग ने कलकत्ता युनिवर्सिटी से बी.टेक तथा आइआइटी खरगपुर से एम.टेक (केमिकल इंजीनियरिंग) की शिक्षा प्राप्त करके प्रशिक्षण विद्यालय के 36वें वर्ग से भाभा परमाणु अनुसंधान केंद्र में कार्यारंभ किया। वर्ष 1993 से आप विभिन्न आकार के यूरेनियम धात्विक उत्पादन एवं निविष्ट यूरेनियम पदार्थो में व्यस्त रहे। इन्होंने आरएन्डडी कार्यक्रमों के क्षेत्र में यूरेनियम पदार्थो की प्रक्रिया विकास तथा उत्पादन संबंधित प्रक्रिया विकास, रूपरेखा एवं अनुप्रयोग में भी काम किया है। राष्ट्रीय एवं अंतर्राष्ट्रीय सम्मेलनो/ पत्रिकाओं में 21 शोध-पत्र इनके श्रेय में हैं।

Mr. S. K. Satpati of Uranium Extraction Division, obtained B. Tech (Chemical Engineering) from Calcutta University and M. Tech (Chemical Engineering) from IIT Kharagpur and joined BARC through 36th Batch of Training School. Since 1993, he has been carrying out activities related to uranium metal ingot production of different sizes and with different input uranium materials. He has also carried out R & D activities in the field of process development, design and application relevant to uranium material processing and production. He has 21 International and National Conference / Journal papers to his credit.

डॉ. (श्रीमती) एस.बी.रॉय ने कलकत्ता यूनिवर्सिटी से सफलता पूर्वक केमिकल इंजीनियरिंग करके प्रशिक्षण विद्यालय के 25वें वर्ग से भाभा परमाणु अनुसंघान केंद्र में वर्ष 1982 में कार्यारंभ किया। तत्पश्चात यूरेनियम धात्विक उत्पादन एवं निविष्ट यूरेनियम रियक्टर ग्रेड के आरएन्डडी कार्यक्रमों के अनुसंधान क्षेत्र के परियोजना इंजीनियरिंग पदार्थो में व्यस्त रहीं। आपने वर्ष 2001 में आइआइटी मुंबई से केमिकल इंजीनियरिंग में पीएच.डी की डिग्री प्राप्त की। इस समय आप भाभा परमाणु अनुसंघान केंद्र के यूरेनियम निष्कर्षण प्रभाग की अध्यक्षता कर रही हैं तथा विभिन्न यूरेनियम मिश्रण की प्रक्रिया एवं उत्पादन हेतु सुरक्षा समिति के सदस्य भी हैं। राष्ट्रीय एवं अंतर्राष्ट्रीय सम्मेलनो/ पत्रिकाओं में 35 शोध-पत्र इनके श्रेय में हैं। आप होमी भाभा नैशनल इंस्टिट्यूट की प्रोफेसर हैं तथा आपको वर्ष 2006 का डीएई सांइटिफिक एन्ड टेक्निकल एक्सिलंस अवार्ड भी प्रदान किया गया।

Dr.(Ms.) S.B.Roy

Dr (Ms.) S.B. Roy, a Chemical Engineer from Calcutta University joined the Uranium Extraction Division in 1982 after successful completion of 25th batch of BARC Training School. Ever since she has been engaged in regular production, related R&D and project engineering activities in the field of research reactor grade uranium metal production. She obtained her Ph.D. degree in Chemical Engineering from IIT, Mumbai in 2001. Presently, she is heading the Uranium Extraction Division, BARC and is a member of various safety committees for processing and production of uranium compounds. She has 35 international and national conference, journal publications to her credit. She is a Professor of the Homi Bhabha National Institute and was conferred with the DAE Scientific and Technical Excellence Award for the year 2006.

आसावरी रथ, ए.यू.सीमा, एवं बी.एन.जगताप द्वारा लिखा “कुआसी-रेज़ोनन्ट टू -फोटॉन ट्रांज़िशंज़ इन एटोमिक यूरेनियम एन्ड दियर एप्लिकेशन टु आइडंटिफिकेशन ऑफ न्युव इवन पेरिटी आटोअयोनाइजिंग लेवल्ज” नामक शोध-पत्र को 10-13 फरवरी, 2009 के दौरान इंटर-यूनिवर्सिटी एक्सेलेरेटर सेंटर, न्यू देहली में आयोजित एटोमिक मोलिक्यूलर एन्ड ओप्टिकल फिज़िक्स (एसएएमओपी -09) पर डीएई - बीआरएनएस की परिचर्चा में सर्वश्रेष्ठ शोध-पत्र पुरस्कार प्रदान किया गया।

The paper entitled "Quasi-resonant Two-photon Transitions in Atomic Uranium and their Application to Identification of New Even Parity Autoionizing Levels" by Asawari Rath, A.U. Seema and B.N. Jagatap received the Best Paper award in the DAE-BRNS Symposium on Atomic Molecular and Optical Physics (SAMOP – 09), held at the Inter-University Accelerator Centre, New Delhi during Feb 10-13, 2009.

Ms. Asawari Rath

श्रीमती आसावरी रथ ने इन्डियन इस्न्टिट्यूट ऑफ टेक्नॉलोजी, मुंबई से (भौतिक विज्ञान) में एम.एससी. के पश्चात भाभा परमाणु अनुसंधान केंद्र के प्रशिक्षण विद्यालय के 40वें वर्ग से स्नातकता प्राप्त की। इस समय आप लेज़र एवं प्लाज़्मा टेक्नॉलोजी प्रभाग के हाइ रेज़ोल्यूशन लेज़र स्पेक्ट्रोस्कॉपी के क्षेत्र में कार्यरत हैं।

Ms. Asawari Rath graduated from the 40th batch of BARC training school, after completing her M.Sc. (Physics) from Indian Institute of Technology, Mumbai. She is currently working in the area of high resolution laser spectroscopy in the Laser & Plasma Technology Division.

Ms.A.U.Seema

श्रीमती ए.यू.सीमा भाभा परमाणु अनुसंधान केंद्र के प्रशिक्षण विद्यालय के 40 वें वर्ग से हैं। इन्होंने कोचीन यूनिवर्सिटी ऑफ टेक्नॉलोजी, कोची से (भौतिक विज्ञान) एम.एससी. की शिक्षा प्राप्त की। इस समय आप लेज़र एवं प्लाज़्मा टेक्नॉलोजी प्रभाग के हाइ रेज़ोल्यूशन लेज़र स्पेक्ट्रोस्कॉपी के क्षेत्र में कार्यरत हैं।

Ms. A.U. Seema is from the 46th batch of BARC training school. She obtained her M.Sc. (Physics) from Cochin University of Science and Technology, Kochi. She is currently working in the area of high resolution laser spectroscopy in the Laser & Plasma Technology Division.

Dr.B.N.Jagatap

डॉ. बी.एन. जगताप, लेज़र एवं प्लाज़्मा टेक्नॉलोजी प्रभाग के एक उत्कृष्ट वैज्ञानिक हैं।

Dr. B.N. Jagatap is an Outstanding Scientist in the Laser & Plasma Technology Division.

Dr. S.L. Chaplot

डॉ. एस.एल. चपलोट, अध्यक्ष, ठोस अवस्था भैतिकी प्रभाग, को अमेरिकन फिजीकल सोसाइटी द्वारा अपनी प्रतिष्ठापूर्ण पत्रिकाओं "फिजीकल रिव्यू लैटरस् तथा फिजीकल रिव्यू" के लिए विशिष्ट रेफरी की मान्यता दी गई।

Dr. S.L. Chaplot, Head, Solid State Physics Division, has been recognized as an outstanding Referee by the American Physical Society for its prestigious journals "Physical Review Letters and Physical Review."

Portrait sketched by Dr. Homi J. Bhabha

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