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HIGH POWER Nd:GLASS LASER SYSTEM FOR GENERATION AND STUDY OF MATTER AT EXTREME TEMPERATURES AND PRESSURES

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The Laser and Neutron Physics Section, Physics Group, BARC, has been involved in studies of extremely high temperature laser-produced plasmas and ultra-high pressure laser-driven shock waves. This work has been pursued over the last several years, using nanosecond and sub-nanosecond high power laser systems, which have been developed indigenously. The latest laser system developed for this purpose, is an intense Nd:Glass laser chain capable of producing laser pulses of 300-800 picoseconds duration and maximum single pulse energy of about 12 Joules. Focused laser intensity on targets is in the range of $10^{12} – 10^{15}$ w/cm^2 [1]. Plasmas produced with such laser intensities have opened up the possibility of studying hydrodynamic phenomena in materials at exceedingly high temperatures (a few hundred electron volts) and pressures (a few ten Megabars) [2]. Such laser-produced plasma has a lifetime of a few nanoseconds and extends over a few hundred of micrometers in space. Diagnostics used to study such plasma, are required to have sub-nanosecond temporal resolution and micrometer spatial resolution [3]. In this report, we describe the development of an intense laser along with its associated sub-systems. Several laser plasma diagnostics which were developed and some of the interesting results obtained in laser-plasma interaction experiments, are also presented.

Intense Pico-second Laser

The 12J/300-800-psec laser system consists of a commercial laser oscillator with an output energy of 100 mJ per pulse, operating at a pulse repetition rate of 10Hz, and a peak to background contrast of 10^4. Since large energy storage Nd:glass amplifiers operate in single shot mode, the oscillator has also been made to operate in single shot mode and is synchronized with the five amplifier stages, by using a specially developed fast synchronization circuit. In order to maintain laser intensity below the damage threshold, successive amplifiers are housed with laser rods of increasing diameters as one moves away from the oscillator. A spatial filter has been incorporated after the second amplifier stage, to remove spatial intensity modulations on the beam profile. A Faraday isolator is placed at the end of the laser chain to block the back reflection of the laser light from plasma. The schematic and the photograph of the laser chain are shown in Fig.1a and 1b. The description of the components of the laser chain is given below.

The laser is operated at a maximum power density of 1Gigawatt/cm^2, in order to avoid laser-induced optical break down in the laser glass. The first amplifier stage is a 19 mm x300 mm Nd: Glass amplifier, pumped by six xenon-filled flashlamps arranged symmetrically around the active medium, yielding a gain of 4-5 at an input electrical energy of 6KJ. The second amplifier also has an identical rod. This amplifier yields a gain of 5-6. The third and fourth amplifiers employ 38 mm diameter, 320 mm long Nd:glass rods, each pumped by 12 xenon flash lamps. The gain from these two amplifiers is approximately between 2x and 2.7x at input electrical

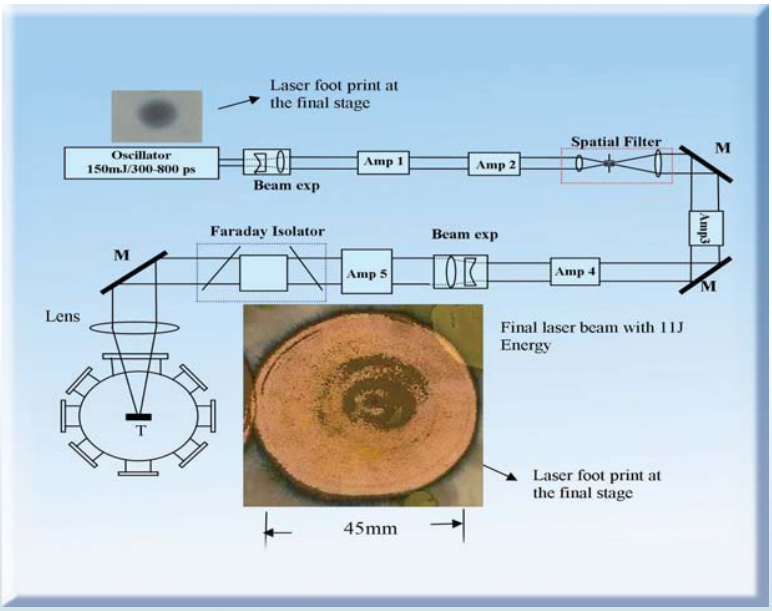

Fig.1a: 10J/300-800 psec laser chain: schematic

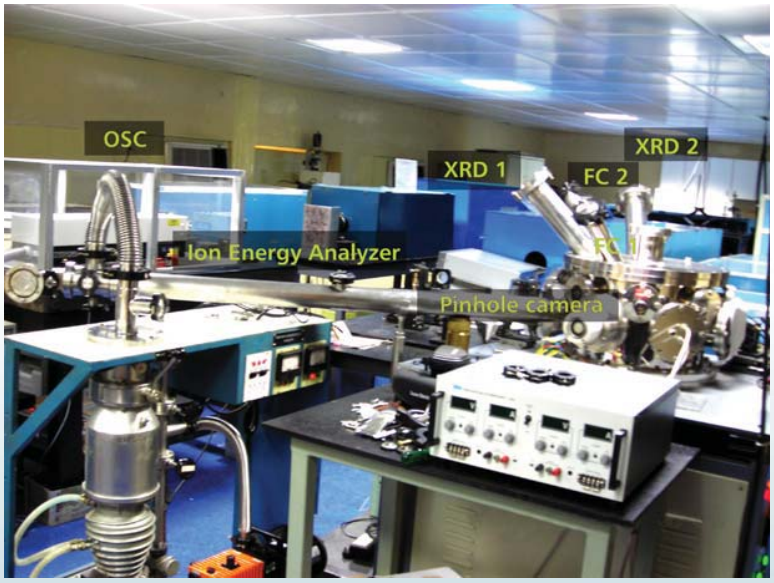

Fig. 1b: 10J/300-800 psec laser chain: photograph

energy in the range of 12 KJ- 15 KJ. As a safety measure, the input energy has been restricted to 12 KJ. The last stage in the chain is a 50 mm diameter, 320 mm long Nd:Glass amplifier pumped by 12 flashlamps. This amplifier has a gain of 1.5. All the large size amplifiers are designed to have a close-coupled cylindrical geometry for pumping. The mechanical design of a pump cavity is influenced by two considerations:1) geometry for efficient energy transfer from the pump source to the laser material and 2) efficient heat removal. Optically pumped lasers have an electrical to optical efficiency of less than 1%. Hence, a large amount of pump energy is dissipated in the laser rod as heat energy. In large diameter amplifiers, where homogeneity of pumping is important, diffused reflectors are used in close coupling which give maximum transfer efficiency for pump light. Saturated sodium nitrite solution is circulated around the laser rods for cooling. Since the thermal conductivity of the Nd: glass material is poor and the flash lamp-heat load very high, the laser system

can only be operated in a pulsed mode, with a single shot in fifteen minutes. The cross section of the pumping geometry of the 38 mm amplifier is shown in Fig. 2a. Xenon flash lamps are used for pumping the laser amplifier rods, because of their high conversion

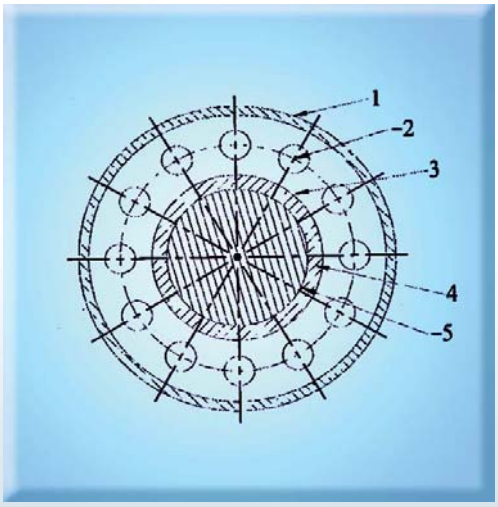

Fig. 2a: Cross section of the pumping geometry of 38mm Nd:Glass amplifier. 1 - Reflector cavity, 2 - Flashlamps, 3 - Glass jacket, 4 - Coolant, 5 – Active medium

efficiency, low cost and easy availability. Xenon flash lamps convert 40 to 60% of the electrical input energy into radiation, in the 0.2 to1.0μm region, which contain most of the major absorption bands of Nd:Glass [4]. Pumping efficiency becomes poor in large diameter rods, due to non-uniform absorption of pump radiation, leading to a spatially varying gain profile as shown in Fig. 2b.

Study of spatial uniformity of gain profile across the large aperture (38 mm and 50 mm diameter) of the amplifiers, showed a 55 to 60% variation in gain, from the center to the edge of the amplifier. The spatial profile across the rod aperture is measured, by measuring the gain at various points along the diameter of the rod. This is done, by simply shifting the input beam

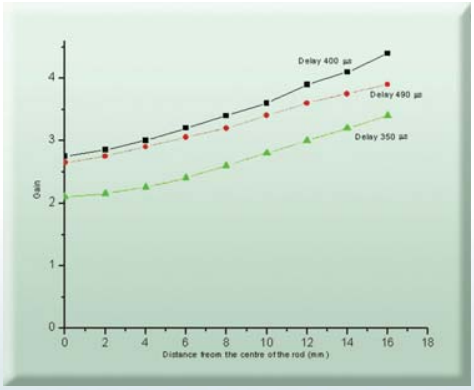

Fig. 2b: Radial gain variation of 38 mm Nd:Glass

horizontally along the rod diameter. The variation of gain along the rod at a fixed input energy and at varying delays of 350, 400 and 490 μs from the start of the flash lamp pulse is measured. It is observed from Fig.2b, that the highest gain of 2.75, at the center of the rod is attained, about 400 μsec after the flash lamp pulse starts. The gain at the edge of the rod is seen to be 1.6 times the gain at the center. The gain curve, corresponding to 350 microseconds delay shows a lower gain due to the fact that the population inversion has not reached the peak value at the time of arrival of the laser pulse. In high power laser chains, incorporating large diameter rod amplifiers, gain variation across the aperture poses problems. Hence, further stages of amplifiers beyond 50 to 60mm diameter would be impractical. This laser system would be upgraded in the near future using disk amplifiers with a clear aperture of 80mm, designed to operate at a gain of about 3x. The limitations faced in the case of large aperture amplifier rods, such as radial gain variation and thermal lensing can be minimized, by using disk amplifiers.

Laser intensity profiles in high power lasers are rarely smooth. This is due to the non-linear growth of high frequency ripples riding over the profile. Such small-scale non-uniformity is acquired in laser beam due to laser medium or optical component in homogeneities,

beam truncation and diffraction effects due to sub-micron size dust particles etc. If these intensity modulations are not filtered, they can cause serious damage to the optical components as well as to laser rods, due to their rapid growth caused by small scale laser self -focusing. In order to mitigate this probability, a spatial filter is essential after a few amplifier stages. In our laser system, we have used a spatial filter after the second amplifier stage and it consists of two lenses L_1 and L_2 (f_1 =60 cm and f_2 = 120 cm) separated by a distance equal to the sum of their focal lengths with a pinhole of 900μm diameter, located at the common focus of the lenses. The lenses and pinhole are housed in a vacuum chamber evacuated to a pressure of 10^{-2} Torr as shown in Fig. 3. Since the spatial filter is introduced between the 19 mm and 38 mm diameter amplifiers, it serves the dual purpose of filtering the higher order spatial frequencies as well as expanding the laser beam to the required size, in order to fill the following larger amplifier. The spatial filter works on the principle that, the input lens produces the Fourier transform of the input intensity distribution at the focal plane. Thus, the high spatial frequencies, corresponding to small-scale intensity modulations of the object, focus on a large distance from the axis and can be easily filtered out, by placing a pinhole of a suitable diameter. On the other hand, the low-frequency component constituting the smooth beam profile can pass through the pinhole unperturbed. The output lens of the spatial filter performs the inverse Fourier transform, projecting the filtered beam pattern onto the image plane. The output aperture of previous amplifier, is image relayed to the input aperture of the following amplifier. The aim is to geometrically transfer the beam intensity distribution onto a desired plane located at the next amplifier, thereby, impeding the growth of high frequency intensity fluctuations, that would otherwise modify the spatial profile of the laser beam, if it was left to propagate freely. The image relaying thus provides near optimal coupling of the beam energy between adjacent amplifiers. We have also introduced an image relaying system (f_1 =50 cm and f_2 = 70 cm) between the fourth and fifth amplifier stages.

As mentioned earlier, a Faraday isolator is used at the end of the laser chain. It works on the principle of Faraday Effect. When a plane polarized light wave passes through a Faraday glass kept in a magnetic field with the direction

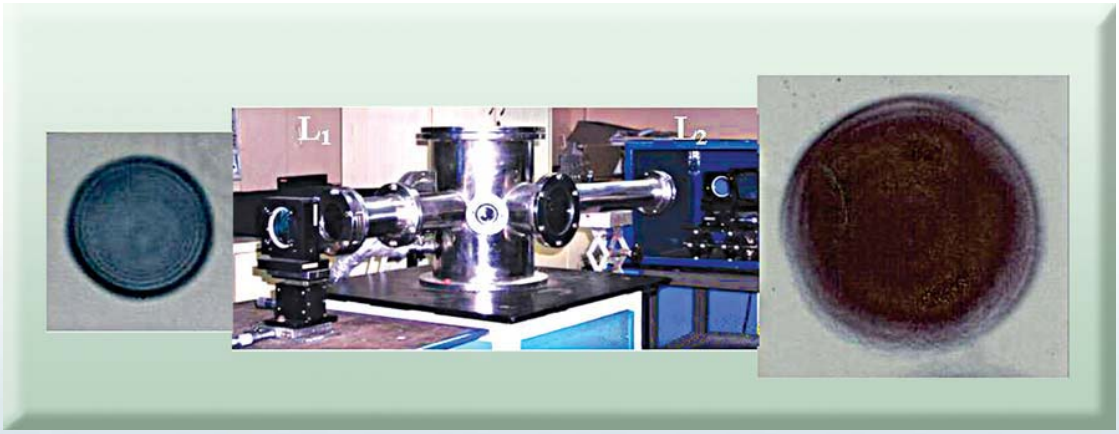

Fig. 3: Spatial filter assembly with beam before the spatial filter and after the spatial filter

of magnetic field parallel to the direction of propagation, the plane of polarization of the incident beam gets rotated. The change in polarization angle q is given by the expression:

$$ø = BVl$$

Where l is the length of Faraday active material, V is Verdet constant, which is a property of the material chosen; B is the magnetic field strength. The schematic setup and the photograph of Faraday isolator is shown in Figs. 4a and 4b. It consists of two polarizers P1, P2 (160 mm x 80 mm x 20 mm) and a Faraday glass FR-5 of M/S Hoya (Tb^{+3} doped silicate glass with 1 wt % Tb doping, thickness of 30 mm and diameter of 60mm). The Verdet constant of this glass is 0.001203 degree/G x cm. This requires that a pulsed magnetic field of 12.46 KG must be generated for 45^0 rotations. The pulsed magnetic field is generated within the Faraday glass by placing it coaxially within a solenoid coil. The solenoid has a length of 150 mm and three layers (135 turns) of silvered copper wire with EE type Teflon insulation wound on a hallow nylon cylinder. The inductance of the coil is 900μF and the resistance is 0.3 Ohms. The magnetic field produced by solenoid is measured by tesla / Gaussmeter. The magnetic field is mapped within the solenoid along axial and radial directions at currents varying from 847A to 1.104KA in order to study the field uniformity. Variation in magnetic field along the axis is observed to a much greater extent as compared to that along the transverse or radial direction, (almost negligible). Therefore, the length of the solenoid is selected to be about 5 times the thickness of glass, so that, there is no variation of magnetic field in the region of interest. The field is found to be fairly uniform with variation of $<$ 4% in the region of our interest.

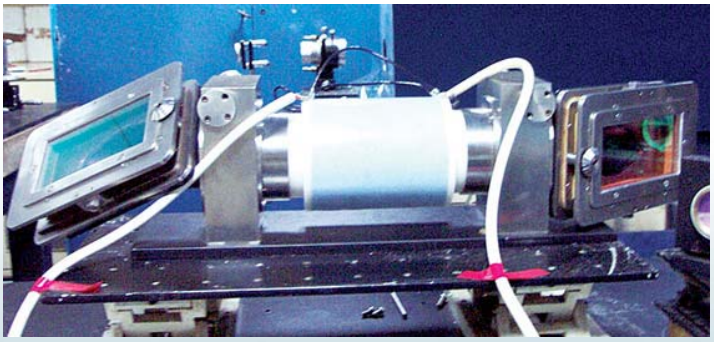

Fig. 4b: Photograph of Faraday isolator

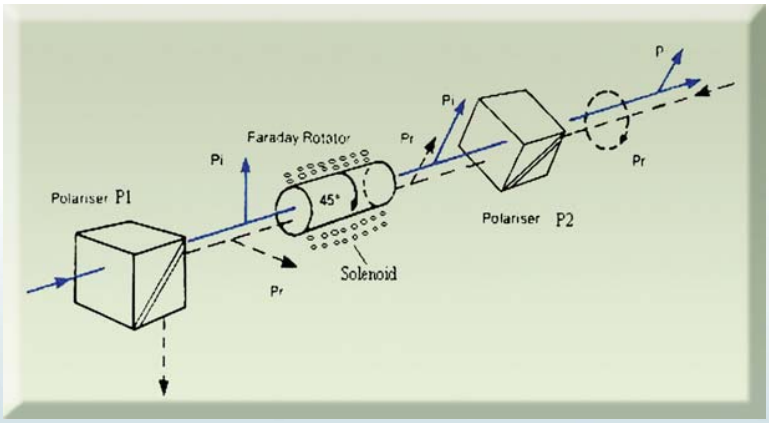

Fig. 4a: Schematic of Faraday isolator

The extinction (ratio of input to back reflected laser intensity) at the centre of the Faraday isolator is found to be 270: 1 and the total transmission loss for input laser measured in the Faraday isolator is about 15 % which is admissible in high power laser systems. The laser pulse exiting from the Faraday isolator has a high peak to background contrast of about 10^4, which is extremely important for laser-plasma experiments.

The power conditioning for the laser system involves the charging of capacitor bank (100 μf, 5 kV) in each power supply to 3 to 5 kV. The total energy stored in the capacitor banks is in the range of several kilo-joules. The entire stored energy has to be discharged through the xenon flash lamps, at precise instants of time, with respect to the oscillator pulse. The different amplifier stages are fired at different time delays with respect to oscillator, depending on the time taken for the population inversion to reach a maximum value (size of the amplifiers and number of flash lamps). The timing diagram for the oscillator, all the amplifier stages and the Faraday isolator is shown in Fig. 5.

The block diagram of the power supply and the control systems is shown in Fig. 6. It consists of a Master control unit, Control modules and Energy storage units.

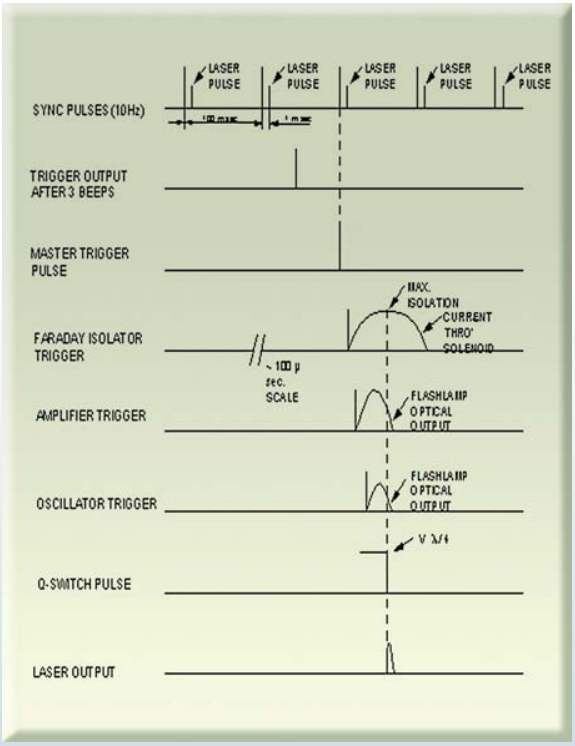

Fig. 5: Timing sequence for various trigger pulses

The energy storage units are connected to various amplifier heads and are controlled by their respective control modules through the master control unit. The master control unit contains the low voltage power supplies required for operation of the system. It also contains the circuits, which give output to the control modules, for initiating the charging of the energy storage units and for triggering the flash lamps when the 'Charge' and 'Trigger' push buttons are pressed. Safety features are incorporated in situations where the flash lamps have to be stopped from firing. In that case, a 'Dump' switch can be activated during the charging process, if it is required to abort the firing of the laser, due to any reason. In this case, the energy in the storage capacitor banks is dumped into resistive loads.

The control modules contain circuits to control the charging of the energy storage units. When the 'Charge' switch is pressed, all the modules, which have been made 'on' initiate the charging of their respective energy storage units. When the required voltage level is reached, the charging stops. If the 'Trigger' switch is pressed at this time (i.e. when all the units have been charged to the required level), a trigger signal is generated at the output of each module, after a specific delay, as set by the delay circuit. This output is used to trigger the flash lamps.

The energy storage units contain circuits for charging the capacitor banks. When the firing of the laser is to be aborted, a contactor dumps the entire energy into high voltage and high power resistors. It also contains circuits for generating the high voltage pulse for triggering the flash lamps. At the end of firing of the laser, any left over energy in the capacitor banks is dumped into resistive loads.

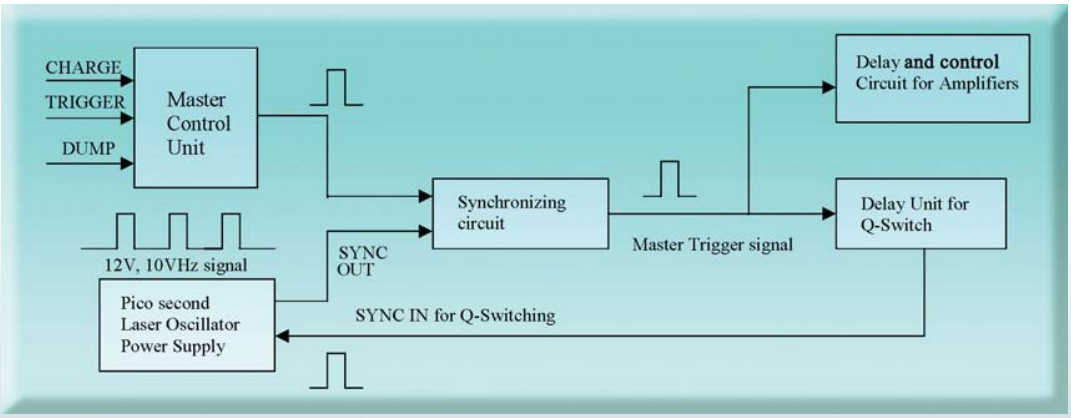

Fig. 6: Schematic of Laser Electronics System

Laser-Plasma diagnostics and experiments

The 12 Joule / 300-800 psec laser pulse propagating out of the last amplifier and Faraday Isolator is finally focused on to the target placed in a vacuum chamber by using a 50 cm focal length f/5 plano-convex lens. The stainless steel vacuum chamber of 40cm diameter and 30cm height with 16 ports for various diagnostic equipment is evacuated to a pressure of $2x10^{-6}$ Torr, as shown in Figs. 7a and 7b.

The targets under study are mounted on a stepper motor controlled x-y-z translational stage, inside the vacuum chamber. Detailed diagnosis of laser target interaction experiments, requires a variety of diagnostics and systems, capable of measurements over a broad range of physical parameters like spatial, spectral and temporal profile of plasma, with high resolution. The laser-plasma studies conducted previously concerned time and space resolved X-ray and ion emissions. The diagnostics used for different measurements for the laser-plasma and laser shock studies are listed in Table 1 along with their specifications.

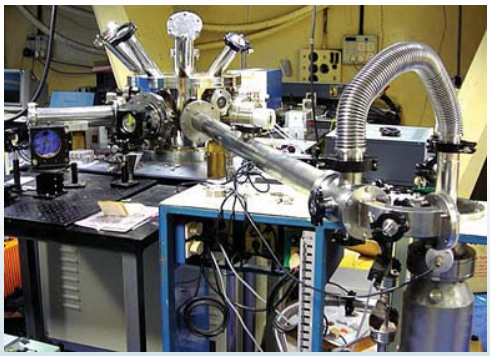

Fig. 7a: Vacuum chamber: outside view

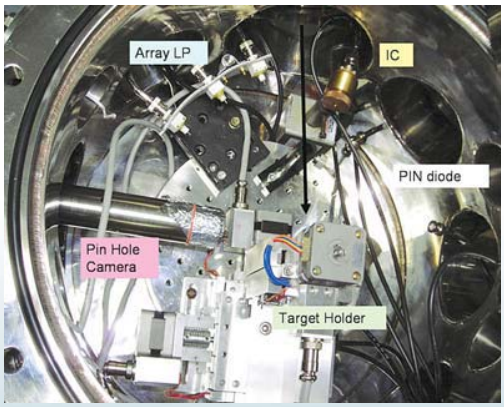

Fig. 7b: Vacuum chamber: inside view

Table 1: Diagnostics used for different measurements for the laser plasma and laser shock studies and their specifications

Diagnostics	Plasma parameter and Specifications	
X-ray semiconductor diodes	Temporal and Spectral-Measurement of X-ray emission from plasma.	Temporal resolution 3 nsec.
7 channel X-ray vacuum photodiode with various energy ranges using various filters.	Temporal and Spectral-Temperature measurement of plasma/shock region.	Resolution –100 psec
X-ray pinhole camera-.	spatial extent of plasma, shock region	Spatial resolution –10 and 25μm
X-ray transmission grating spectrometer–	Spectrum of the emitted x-ray from laser plasma	Spectral Resolution -6Å
Crystal Spectrometer with TlAP and RbAP crystal are in advanced stage of development	Hard x-ray spectrum of laser plasma	Spectral resolution - 0.01Å
Langmuir probe-	Ion velocity, ion temperature, ion current, charge state measurement,	
Faraday Cup (IC)	Time-of-flight (TOF) spectroscopy of ions- Ion velocity, ion temperature, ion current, ion charge state etc.	Able to resolve fast ion components
Electrostatic Ion Energy Analyzer is being tested for the ion energy to charge state spectrum measurements.	measurement of the energy to charge (E/z) spectrum of the ion species, charge state abundance,	
Optical streak camera	Shock velocity and target velocity measurements	Resolution -20pec
VISAR set-up	Particle velocity measurement	

Experiments on laser-plasma interaction

X-ray and Ion emission studies from Cu-Au alloy target

In most of the experiments described below, the laser pulse had a maximum energy of 2Joules and a pulse duration variable from 300-800psecs. The laser pulse had a high peak-to-background contrast. In large laser systems pre-pulses are frequently observed, before the onset of the main laser pulse. It is also common to have a weak background on which the main laser pulse is seen to override. In such a condition, targets exposed to pre-pulses or background laser radiations can get ablated, before the arrival of the main laser, leading to complex results. However, in our laser system, pre-pulses were absent and peak-to-background contrast was more than 10^4. The focused intensity on the target can be varied from 10^{13} to 10^{14} W/cm^2. The plasma is formed in the early rising part of the laser pulse, when intensity exceeds 10^{11}W/cm^2. The remaining part of the laser pulse is absorbed in the plasma by various mechanisms and heats the plasma to a temperature of 100 to 500 eV. The typical temperature and density profiles in space and time have been simulated using a one-dimensional Lagrangian hydrodynamic simulation code, including radiation hydrodynamics and are shown in Fig. 8. Such a high temperature, high density plasma is a strong source of broadband, incoherent x-rays, hot electrons and fast ions. We have characterized the x-ray emission as well as ion emission from targets with varying atomic numbers. Scaling of X-ray emission with laser intensity has been recorded for simple metallic and metallic alloys of 1mm thickness, using the X-ray pin diodes placed at 45^0 with respect to target normal. Fig.9 shows the comparison of X-ray emission from pure copper and gold targets with that of an alloy of copper and gold (0.47Au+0.53Cu - atomic composition). It was observed that for an incident laser energy of 1.4 J, there was a ten fold and two fold enhancement in X-ray emission from the Au+Cu mixed target, as compared to pure copper and gold targets in the spectral region 2.5Å-5Å respectively; five fold and one and a half fold increase in the spectral region 1Å-2.5Å respectively.

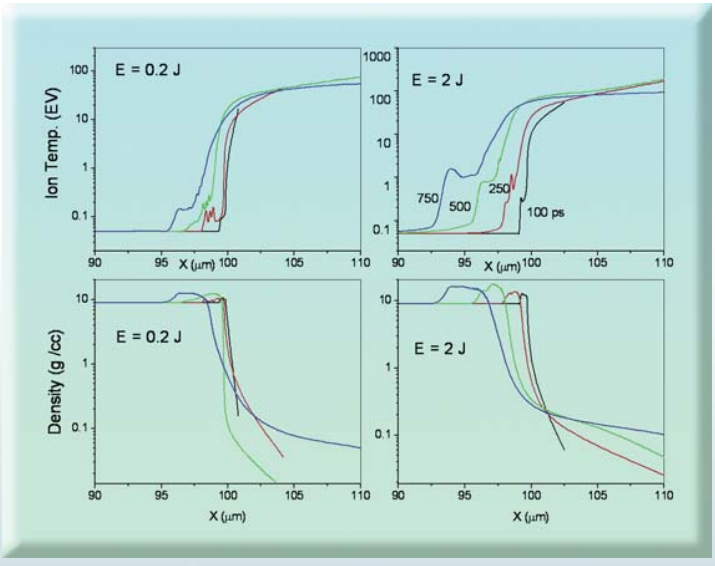

Fig. 8: Spatial profiles of ion temperature and density for laser energy 0.2 Joule and 2 Joules

Motivation for these experiments was derived from reports which showed that, when two or more elements are mixed such that the high opacity region of one element overlaps with the low opacity region of the other, the mixture will have a higher mean opacity as compared to that of the individual elements. A higher opacity reduces conduction loss and leads to a higher re-emission of absorbed radiation, thus increasing the overall coupling efficiency, between the

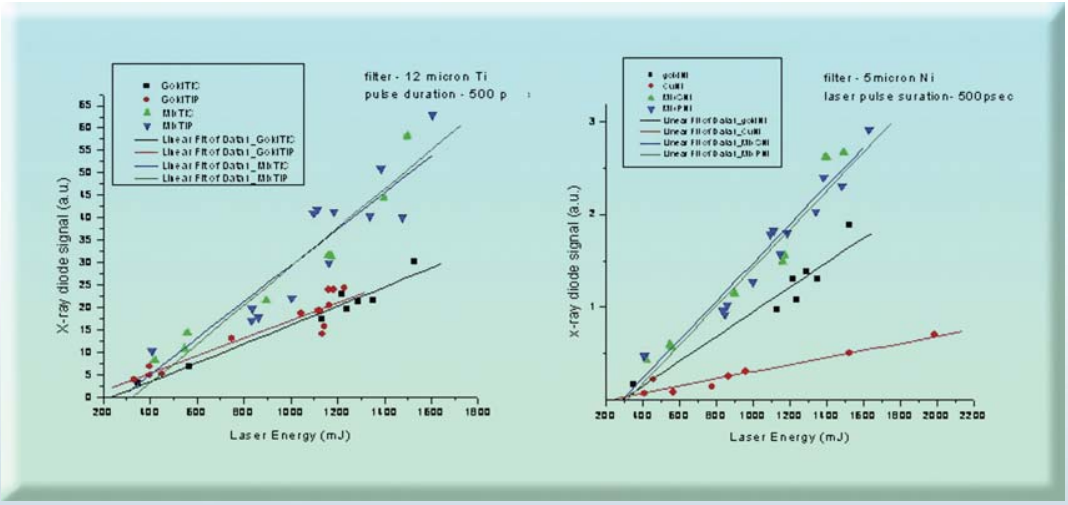

Fig. 9: Comparison of X-ray emission: pure Cu and Au with that of Cu +Au alloy

laser and target. Recently, cocktail targets, which are combinations of elements: Au-Gd, Au-Sm, Au-Nd, Au-Cu etc., have been proposed [4-6] for the hohlraum cavities used in Inertial Confinement Fusion studies with intense lasers. It has been shown that a 50% increase in the hohlraum wall opacity results in a 12% lower laser energy requirement to attain the same hohlraum temperature [7]. Interesting features have been observed in the ion dynamics of such mixed targets too. Ion velocity and ion current and their angular distributions have been measured, using array of Langmuir probes and Faraday cups placed at 13^0, 30^0 and 45^0 with respect to target normal. Fig.10 shows the ion current recorded by Langmuir probe. It is clearly observed that the peak current in a mixed target is about 1.3 times higher than in copper and 3.37 times higher as compared to gold. The ion velocity should have been the highest for copper targets considering its low mass and lowest for gold target because of its higher atomic mass. The average ion velocity for the mixed targets should have been somewhat in between. However, it is seen that the average ion velocity in case of the mixed target is about 1.4 times higher as compared to copper target and almost 2 times higher as compared to gold. This could be an indication of a higher plasma temperature, perhaps leading to an enhanced x-ray conversion in plasmas from mixed targets.

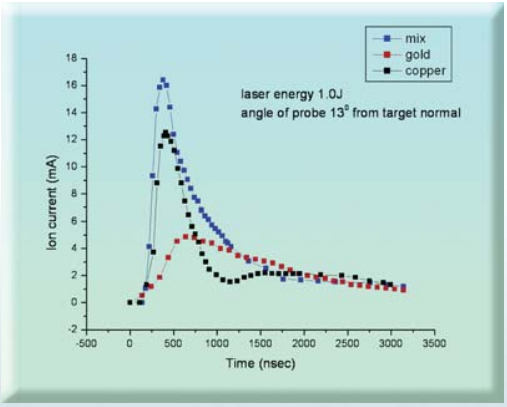

Fig. 10: Ion current recorded by Langmuir probe

Nano Ion emission from copper targets with a copper-nano-particle layer

It has been proposed by some authors, that targets having surface nano-structures can lead to a better

coupling of laser light through surface plasmons. Most of these studies have been made with sub-picoseconds laser pulses in the laser intensity range of 10^{15} to 10^{16} W/cm^2. In our experiments, we are using a laser pulse duration three orders of magnitude larger in a lower intensity range. Whereas, other authors have indicated enhancement of laser absorption in nano-particle coated targets by measuring X-ray emission in soft or hard region, we have come to this conclusion by monitoring the ion flux emitted from the plasma. Ion flux measurement is more directly related to laser absorption than observing X-ray emission in a limited spectral region. The scaling of ion densities and ion velocities with laser pulse energy for two polarizations are shown in Fig. 11. In conclusion we can say that nano-particle coating on plane targets of high Z materials can lead to better laser absorption for P polarized light for sub-nanosecond pulse duration.

Thermo-luminescent dosimeters: absolute measurement of X-rays from laser-produced plasma

Measurement of the absolute brightness of X-ray or soft X-ray (SXR) sources such as laser-produced plasmas, play an important role in complete characterization of such a source. Calibrated detectors are required when both the conversion efficiency of laser radiation into X-ray radiation and the absolute spectral brightness are needed.

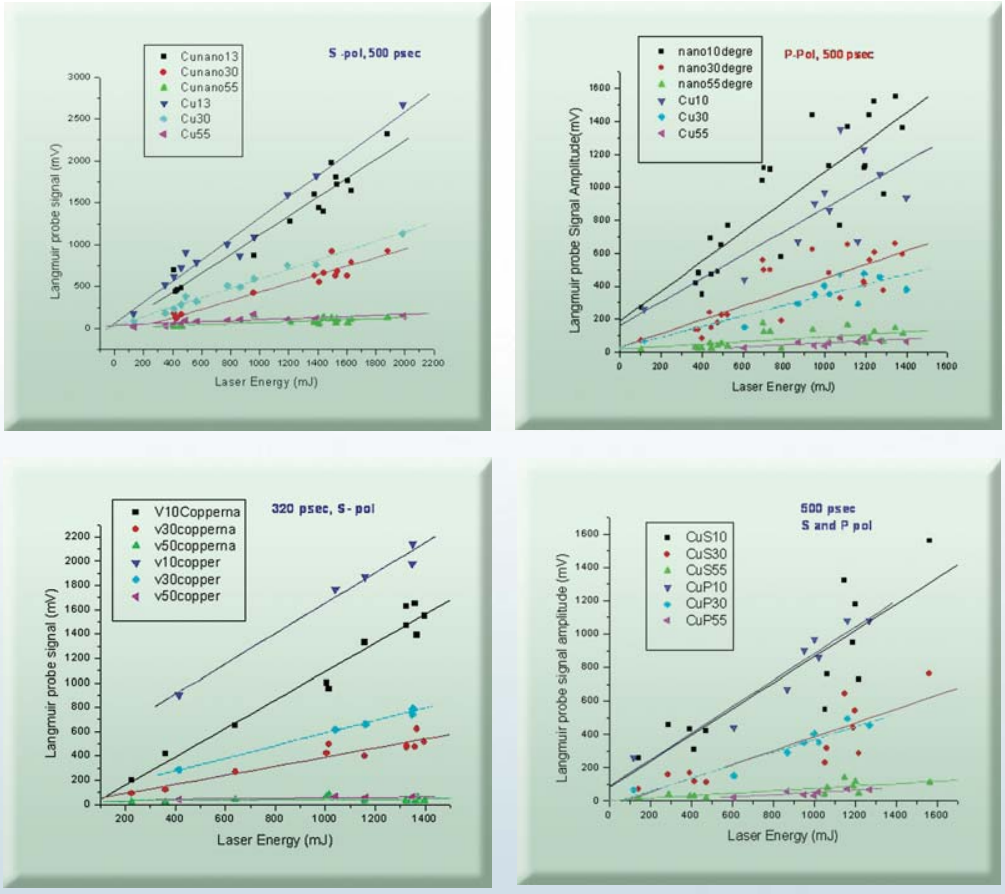

Fig. 11: Scaling of ion densities and ion velocities with laser pulse energy for two polarization measured by set three of Langmuir probes placed at various angles.

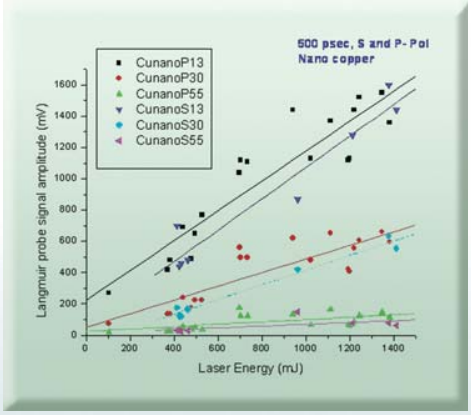

Fig. 11: (contd.) Scaling of ion densities and ion velocities with laser pulse energy for two polarization measured by set three of Langmuir probes placed at various angles.

If time integrated doses of X- rays are to be measured, TLDs are at an advantage.

The X-rays generated were measured using powder $CaSO_4$: Dy (grain size varying from 53 -150 μm) thermo luminescent dosimeter with the various filters - polycarbonate (transmission-> 1KeV), B-10 (transmission >700 eV), 2μm Al (transmission 0.8-1.56 Kev, >2.1Kev), 5 μm (transmission >2.5Kev) Al, and 10μm (transmission > 4 Kev) filters. The $CaSO_4$:Dy (0.05 mole %) phosphor, prepared by recrystallization technique, was used to detect the X-rays generated in high power lasers. The $CaSO_4$: Dy phosphor exhibits dominant TL peak around 220 ^oC with a small TL peak around 100 ^oC. The powder was annealed at 400 ^oC for 1 hour to erase any residual TL. The thermo luminescence spectrum was recorded using indigenously developed TL reader at BARC, which has a data acquisition facility and is computer-controlled. The heating rate was kept at 4^o C/s. The glow curves (as shown in Fig. 12) were recorded during read out of the TLDs and the area under the glow curve gives a measure of X-ray dose. The X-ray doses to the TLD placed at a distance of 80mm from the plasma, with the filters B-10, 2 μm Aluminium and 6 μm polycarbonate, 5 μm Aluminium and 12 μm Aluminium for a single laser shot are 287.1 mGy, 131.5 mGy and 96.2 mGy, respectively and 21.42 mGy and 9.05 mGy respectively.

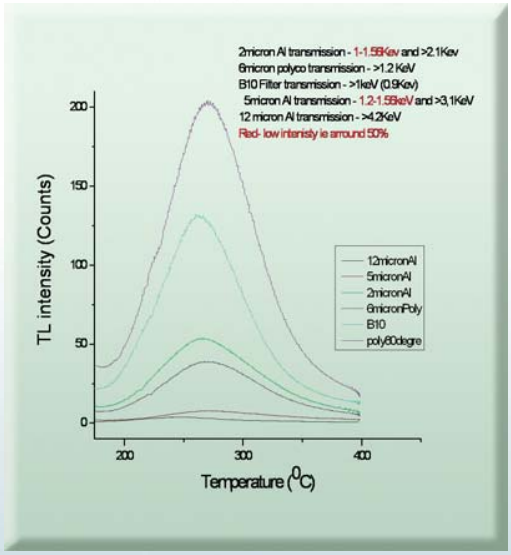

Fig. 12: Glow curve of TLD ($CaSO_4$:Dy) with various filters

It is very clear from the data observed that the x-ray emission from laser- produced plasma is more in longer wavelength region and decreases very rapidly for lower wavelength.

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BARC NEWSLETTER

MICROFOULING PROBLEM IN ACID TRANSFER UNIT OF BORON PLANT

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Introduction

Recently, a severe microfouling problem was encountered in the Boron Enrichment Plant at IGCAR, Kalpakkam, which led to eluent flow blockage. It was observed that in spite of highly adverse environment (very low pH, no apparent carbon source) for survival, microorganisms have survived, grown and clogged the pipeline. Extensive biomass was observed at various regions in the piping used for transferring the eluent, 0.1N HCl. Detailed studies led to isolation of five different types of microorganisms: two fungi and three bacteria. The dominant fungus was identified as *Cladosporium sp*. The studies indicated that Ebonite rubber lining of the pipelines was the plausible nutrient source for the microbes. Sodium omadine, an antifungal biocide was tested and found to be quite effective against the fungus. However, since biocide addition is not compatible with the process used in the boron plant, alternative control strategies needed to be employed.

Microorganisms exist predominantly as multicellular surface attached communities, called biofilms. Biofilms invariably develop on solid surfaces exposed to aquatic systems. Industrially, biofilms pose problems in cooling circuits, wherein they cause pressure drop in pipes, reduce heat transfer efficiency in condensers and impair the performance of ancillary cooling systems. The initial phase of biofilm growth is influenced by the ambient water quality as well as by the nutrient chemistry at the solid/liquid interface. Later, the metabolism of the microbes colonizing the surface, alter the chemical milieu. Generally, the exopolymeric matrix of the biofilm contains key constituents from bulk water, resulting in an enriched nutrient environment. Apart from this, the material surface can also provide nutrients for an attached microbe.

Many polymeric materials are considered to be inert to microbial attack. However, these materials may still function as a support for biofilm formation. Plastics and rubber materials often contain additives and impurities, that may leach from the matrix to the surrounding environment. The biodegradation of plastics and various rubber products, plays an important role in environmentally-compatible methods for their disposal. Commonly, if a polymer is to be used as a source of nutrition for biological growth, it has to be broken down to molecules small enough to be transported across the cell membrane. Surface degradation is an interfacial process depending on several parameters. Anionic compounds released during microbial metabolism, react with cationic constituents and form salts. An increase in the salt concentration or a drop in the pH due to the microbial activity at the interface, can facilitate the breakdown of the polymer matrix. Microorganisms can also incite the breakdown of insoluble polymeric materials, by the production of exoenzymes, which are capable of mediating degradation outside the cell. It has been reported that silicone rubber voice prostheses degrade

under the influence of a mixed species biofilm. Likewise, when a silicone rubber insulator is covered by a hydrophilic biofilm, the hydrophobic surface properties of silicone are reduced. This has been shown to cause an increase in current leakage under wet conditions, as compared to clean insulators. Therefore, materials that seem to be inert for degradation in laboratory studies, may encourage microbial growth, when exposed to outdoor conditions.

Infestation of rubber / plastic lined pipelines by microorganisms, can cause serious problems in process plants and can affect the quality of the end product. We report here a recent microfouling problem in Boron plant (see box) at Kalpakkam (Fig.1). The study describes how fungi can use the ebonite (see box) lining of carbon steel pipeline, as a source of carbon and energy at very low pH (1.5).

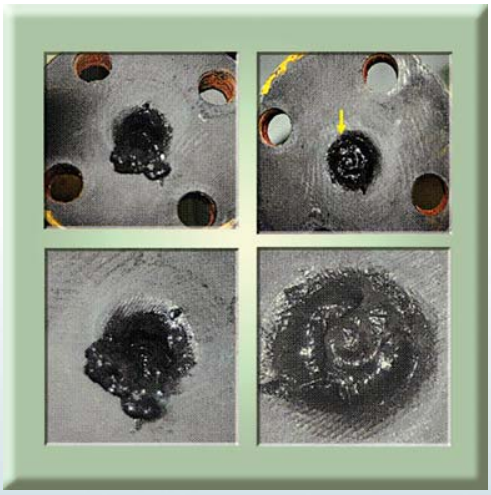

Fig. 1: Clogged pipeline with fungal biomass

Boron Plant

The technology for enrichment of Boron is based on ion exchange (IX) chromatographic principles. Commercial grade HCl, diluted using demineralized (DM) water, is used as eluent and fed to IX columns using metering pump. Ebonite-lined carbon steel is the material of construction for columns and piping. Boric acid solution is fed into IX columns to develop Borate band. The enrichment of ^{10}B takes place due to the movement of Borate band in the IX columns. Sodium hydroxide is used for regeneration of resin beds.

The fouling biomass extracted from the pipelines (Fig. 2) was used for isolating bacteria and fungi. Microscopic observation was made with the native biomass after staining with different dyes (Fig. 3). The laboratory cultured microbes were also stained similarly and observed under the microscope. To identify the source of carbon for the fungus, the rubber scrapings from the pipelines were added to the medium containing HCl solution in DM water (pH 1.5) and the culture vessels were incubated at room temperature. The growth of the fungus on the rubber scrapings was monitored microscopically. Laboratory studies to control fungus growth were carried

Fig. 2: Biomass collected from fouled pipeline

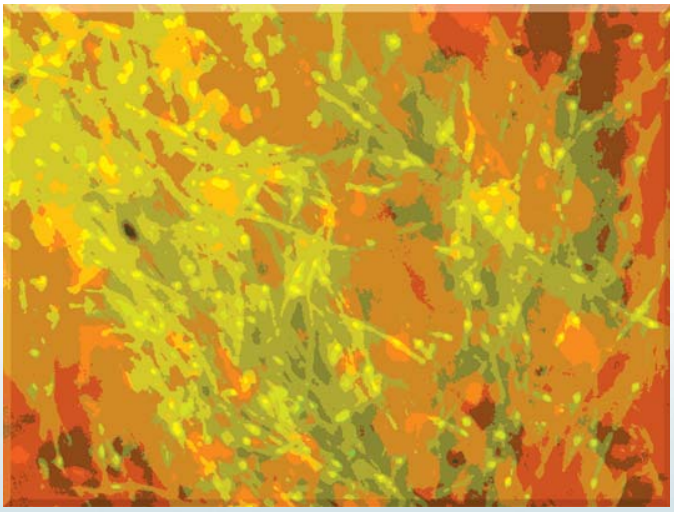

Fig. 3a: Fungal biomass from pipeline stained with acridine orange (450X)

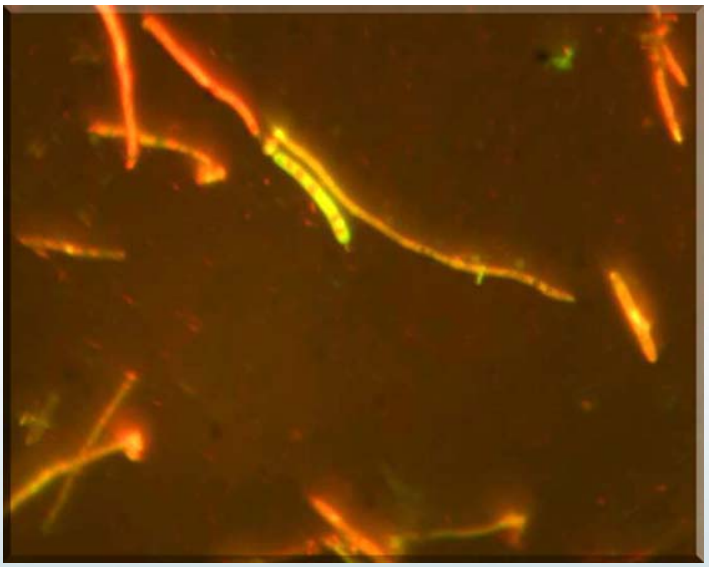

Fig. 3b: Fluorescence microscope image of fungal mycelium showing nuclear (1000X) material stained with acridine orange

out both in static and dynamic conditions. Chlorine and Sodium omadine (antifungal biocide) were tested.

Little is known about the process of rubber degradation and the enzyme machanism involved. The term natural rubber or caoutchouc (from Indian: caa - tears; ochu - tree; cahuchu - weeping tree) refers to a coagulated or precipitated product obtained from the latex of rubber plants (*Hevea brasiliensis*), which forms non-linked but partially vulcanizable polymer chains with elastic properties, having molecular masses of about 10^6 Daltons. Natural rubber consists of isoprene units, each containing one double bond in the *cis* configuration.

Ebonite

Carbon steel lines are generally given rubber lining (Ebonite) to make them resistant to attack by corrosive media like acids, alkalis and salt water. Ebonite is a highly cross-linked material, obtained by heating a mixture of raw rubber and sulfur at >150 °C, resulting in hard, thermoset product. Chemically, it is ~50% sulphur polymerized with isoprene. The lining is applied as un-vulcanized rubber to metal surfaces and then vulcanized, to strongly bind the rubber to the metal surface as a protective lining. In this way, rubber can be bonded to various materials.

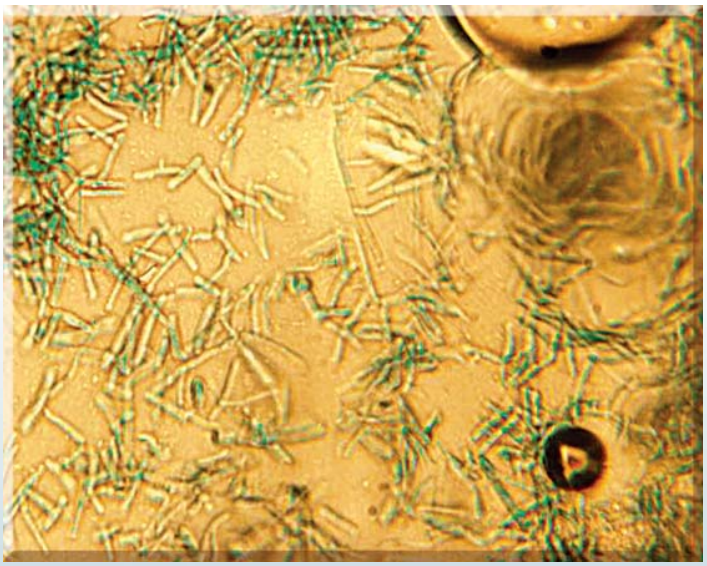

Fig. 3c: Fungal mycelium stained with cotton phenol blue (1000X)

Fig. 4: Fluorescence image of fungal biomass on the ebonite scrapings (400X)

Microscopic observation showed the presence of filamentous biomass (Figs. 3a, 3b). Staining with cotton phenol blue confirmed that the biomass was of fungal origin (Fig. 3c). Totally five different predominant forms of organisms were isolated: two fungi and three bacteria. Among the two fungal isolates, one fungus belongs to family Deuteromycetes (i.e., yeast) while the dominant fungal species belonged to the genus Cladosporium (see box). Fig. 4 illustrates the laboratory growth of the fungal biomass on the ebonite scraping, with pH 1.0 HCl solution. After 10 days of incubation, the culture flask with rubber scrapings showed significant growth of the fungus. In the control set, no growth was observed. The fungus was checked for culture purity and was confirmed by fluorescence microscopic observation. The infested ebonite scraping samples were processed for electron microscopy observation.

In order to penetrate the polymer matrix, the fungal hyphae cause cracks and pores in the material. The mechanism of penetration of the mycelium is still unclear, but it is theorized that the hyphae are able to create high turgor pressures, that force the cells through the material. This leads to a decrease in mechanical stability and offers

a way for water to enter the polymeric material matrix. Many fungi develop powerful enzyme systems with the ability to degrade highly stable polymeric structures. Among these, the white rot fungi are exceptional. It has been reported that the white rot fungus *Phanerochaete chrysosporium* is able to degrade PDMS (Polydimethylsiloxane is the most widely used silicon-based organic polymer in industry) as well as lignin through peroxidases.

Cladosporium is the most common member of the so-called black molds. It produces a black pigment that protects it from ultraviolet light. The spore dispersal characteristics are responsible for its distribution and abundance in the environment. It is a slow-growing fungus that produces velvety, dark greenish-brown / blackish colonies on culture media. The hyphae, conidiophores and conidia are pigmented. Cladosporium are ubiquitous and the most common fungi found in the air, soil, foodstuffs, paint, textiles, bird feathers and on plants. The fungus breaks down aromatic ring compounds to simpler hydrocarbons and utilizes them for its metabolism. It is reported that the fungus *Cladosporium resinae* is the main causative agent in aircraft fuel tank failures and produces a bio-surfactant that degrades fuel by allowing water to partially mix with it creating an emulsion; this affects the combustive qualities of the fuel.

This study showed, that the rubber lined pipes can undergo microfouling. The best solution for the problem is to replace the piping with acid-resistant material. If rubber lining is unavoidable, biocides such as omadine can effectively control the fungal growth. Till date actinomycetes were reported to be the only microorganisms able to considerably degrade natural rubber and use hydrocarbon as a sole source of carbon and energy. Recent studies indicate that these microorganisms degrade only *cis*-1, 4-isoprene molecules and generally not the *trans* isomer. It can be conjectured that the *cis* polymer has the configuration to bind to the enzyme protein and to the catalytic domains. Polymerized natural rubber and other poly-isoprenoids are the only biopolymers, whose mechanism of cleavage is still not clear. One route is the analyses of degradation products, which can throw light on the probable biodegradation pathway.

In course of our investigation, we inspected the resin beds of the ion exchange columns located down stream too, for infestation by the fungi. The resin samples also tested positive for the fungal mycelia microscopically. Later, the resin beds were cleaned and regenerated. The plant piping was cleaned by a detailed procedure. Control studies indicated that chlorine will not be effective in controlling the fungus at low pH conditions. However, omadine an antifungal biocide completely controlled / inhibited the growth of the fungus.

Conclusions

- The problem of microfouling due to the fungus growth was noticed in the boron plant on three occasions and simple cleaning did not solve the problem. The fungal growth was luxuriant, almost clogging the whole pipeline.
- The predominant organism was found to be *Cladosporium sp*.
- It was shown that ebonite rubber lining of the pipeline provided the carbon source for the fungus. Low pH conditions in fact favour fungal growth.
- Chlorination at low pH is not effective in controlling the fungus. Addition of other biocides or bio-dispersants will remove the biomass. However, it will interfere with chemical processes in Boron enrichment.
- Alternate materials which are acid-resistant can be used for replacement of acid storage tank and pipelines.

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BARC NEWSLETTER

REMOVAL OF RADIOACTIVE CESIUM, STRONTIUM AND COBALT FROM LOW-LEVEL LIQUID WASTE AT KAKRAPAR ATOMIC POWER STATION

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Radioactive low-level liquid waste, is generated during operation and maintenance of Pressurized Heavy Water Reactors (PHWRs). The liquid waste mainly contains H-3, Cs-134+137, Sr-90, Co-60, Zn-65, Mn-54 etc. Among these radionuclides, the major activity is due to H-3 which is a low-energy beta emitter, with an average energy of about 6.0 keV. Apart from the H-3 activity, the other important radionuclides which contribute to the activity of the liquid waste are: Cs-134+137, Sr-90 and Co-60. Generally, low-level liquid waste is diluted and then discharged into the near-by water body as per standard waste management practice. If the liquid waste containing these radionuclides is discharged into the water body, accumulation of these low-level radionuclides may occur in the water body. Later, these radionuclides may enter the aquatic food chain and ultimately contaminate human beings by giving rise to environmental radiation exposure.

To avoid radionuclides entering the environment, it is essential to remove them from the liquid waste, before dilution, to As Low As Practicable (ALAP) levels to attain As Low As Reasonably Achievable (ALARA) environmental radiation exposure after dilution.

To achieve this objective, inorganic sorbents such as Copper Iron Hexacyanoferrate-II (CUFe-HCF) coated acrylic fibres were prepared and used for removal of Cs-134+137 and Manganese dioxide coated acrylic fibres were prepared and used for removal of both Sr-90 and Co-60. To validate the removal of all these radionuclides by using chemically-coated acrylic fibres, a study was undertaken on plant scale at the Kakrapar Atomic Power Station (KAPS).

CUFe-HCF coated acrylic fibres (5 kg) and MnO_2 coated acrylic fibres (2 kg) were packed in a cylindrical vessel made of mild steel, with a capacity of 130 litres. Inside the vessel, these chemically coated fibres were kept in between blank acrylic fibre beds (1 kg each) and henceforth referred as filter column, as shown in Fig. 1. Liquid waste was poured through the filter column through the inlet from top to bottom. After removal of these radionuclides, the liquid at the bottom of the vessel was drained through outlet at the top. The filter column thus made was connected to the tank containing the liquid waste (4000 litre) as shown in Fig. 2. The liquid waste was then passed through the filter column at the flow rate of 20 litre per minute using a pump. On one

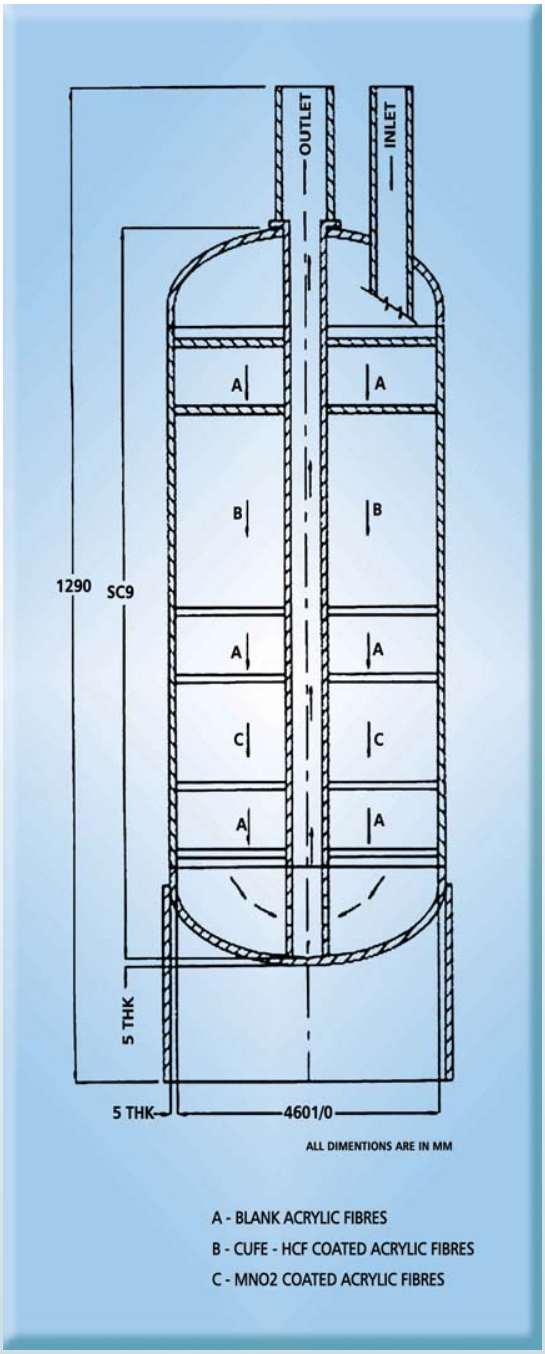

Fig. 1: Filter column

Fig. 2: A view of filter column connected to liquid waste storage tank during plant scale decontamination

complete circulation of the total volume of the liquid waste, about 65 % of gross beta activity was removed and after twelve complete circulations, about 80 % of gross beta activity was removed. Radionuclides such as Cs-137, Cs-134, Co-60 and Sr-90 were removed to the extent of about 56 %, 53 %, 53 % and 95 % respectively on one complete circulation of the liquid waste through the filter column. After 12 such complete circulations, about 80% of Cs-137 and Cs-134 were removed from the liquid waste, however further removal of Co-60 and Sr-90 was not observed.

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BARC NEWSLETTER

51ST GENERAL CONFERENCE, IAEA, VIENNA STATEMENT BY DR. ANIL KAKODKAR, CHAIRMAN, ATOMIC ENERGY COMMISSION AND LEADER OF THE INDIAN DELEGATION

" Mr. President,

Let me first of all congratulate you on behalf of my Government and on my own behalf, on your election as President of the 51st General Conference. I am sure, under your able Presidentship and with the support of your team and the Secretariat of the Agency; this General Conference will be able to accomplish the tasks before it.

I also take this opportunity to welcome the entry of Kingdom of Bahrain, Republic of Burundi, Nepal, Republic of Congo and Republic of Cape Verde to the membership of the International Atomic Energy Agency (IAEA).

Over the past half century, the growth of the Agency and India 's nuclear energy programmes have evolved side by side. The Agency has contributed immensely to harness the benefits of nuclear energy and its applications for all mankind. India, home to a sixth of global population with a sound and time-tested philosophy of life, too has evolved its own nuclear technological capability, realized on the basis of self-reliant domestic development for the welfare of its people. Our Bhabha Atomic Research Centre Training School which has provided almost the entire human resource for our nuclear programme has also completed fifty glorious years and our Prime Minister was with us only a fortnight ago for the graduation function of its 50th batch.

Dr. Anil Kakodkar at the conference

On the occasion of its 50th anniversary, it is gratifying to recognize the unique place that the IAEA has within the UN system. The prestige, credibility and authority of IAEA in this new century rests to a very good measure on the consistent good work done by its Secretariat under the wise leadership of Dr El Baradei especially for the past critical decade. My delegation would like to pay handsome tributes to the Director General and the dedicated staff of IAEA for their professionalism, impartiality and core competence in serving the Member States in accordance with the Statute of the Agency. IAEA's achievements in the past half century have much to contribute to rekindled hopes for a peaceful atom in coming years.

Mr. President,

The world today is at the threshold of a paradigm shift. There is greater awareness today than ever before about the serious consequences to humanity as a whole arising out of the threat to global climate which seems to be at the cliff edge. This situation has come about as a result of unmindful and unsustainable use of fossil energy by a small fraction of world population in industrially advanced societies. On the other hand, a larger part of world population is now on a rapid economic development path. It would require enormous amounts of energy resources to bridge the deficit between the emerging demand and current supply which is very low in the developing world even compared to global average per capita energy consumption. It seems impossible to sustain a tension-free society with 20 or 30 times less per capita energy access in the current interdependent world so closely connected through modern-day communications. It is estimated that meeting development aspirations of these large populations which are now well capable of buying their necessities would raise serious energy sustainability issues and consequent escalation of fuel prices that would affect us all. One needs to look at nuclear energy in this context. Energy associated with processes involving the nucleus of an atom is several million-fold higher than the energy associated with processes that involve electrons that orbit around the nucleus. The latter forms the basis of energy through burning of fossil fuels. Thus, a kilogram of uranium can be a source of a million times more energy as compared to a kilogram of coal or a kilogram of hydrocarbons. Non-emission of greenhouse gases that have threatened the global climate is also a feature of nuclear energy that is catching the imagination of even some of those who earlier opposed it. As a matter of fact, nuclear energy released through fission or fusion of atomic nuclei and solar energy that we receive from the sun are the only two viable basic energy sources capable of meeting our long-term energy needs. We also cannot escape the fact that the sun derives its energy from nuclear fusion. There is, however, a serious fear of the unknown. Such concerns are natural and have been faced by humankind whenever there has been a paradigm shift in things around it. Whether it is in learning to live with fire or advancing from horse carriages to locomotives and automobiles, man has gone through similar dilemmas. But eventually, he has mastered the new technology and accessed its benefits, overcoming the fear of the unknown. In the absence of such foresight and conviction, we could not have made progress. In the case of nuclear energy we are, however, talking on an altogether different scale. Given the population pressure and the need to provide a good quality of life to all, we must evolve ourselves as a society that can benefit from this high-intensity energy source without the risk of its misuse.

Mr. President ,

India with its one billion plus aspiring population and one trillion dollar economy with steady 8% plus GNP growth requires enormous amounts of sustained and reliable energy supply. It is estimated that India would need around 7000 TWh of electricity annually and an additional and larger quantum of primary energy to meet requirements of fossil fluid fuel replacement. While accessing this huge energy supply is a major challenge, we are also fully conscious of the environmental impact of such growth in energy use particularly if it takes place in the business-as-usual mode. In this context, I would like to draw your attention to what our Prime Minister said at the recent Heiligendamm meeting and I quote, " India 's GHG emissions are among the lowest in per-capita terms. Moreover, being only around 4% of the world's emissions, action by us will have a marginal effect on overall emissions. Nonetheless, we recognize wholeheartedly our responsibilities as a developing country. We wish to engage constructively and productively with the international community and to add our weight to global efforts to preserve and protect the environment. We are determined that India 's

per-capita GHG emissions are not going to exceed those of developed countries even while pursuing policies of development and economic growth. We must work together to find pragmatic, practical solutions, which are for the benefit of entire human kind". unquote

Mr. President ,

India has been pursuing its robust three-stage nuclear programme designed to maximize the energy potential from its domestic uranium and thorium resources and contribute around 25% share of electricity generation in the country by the year 2050. The objective is to realize the huge energy potential that is realizable from these nuclear energy resources without having to add to the global carbondioxide burden. The programme is moving ahead steadily with the first stage consisting of indigenously developed Pressurised Heavy Water Reactors (PHWRs) well into a commercially successful programme. The second stage has commenced with the construction of 500 MWe Prototype Fast Breeder Reactor (PFBR) which is now fairly advanced. The third stage is about to begin with the start of construction of a technology demonstrator, the 300 MWe Advanced Heavy Water Reactor (AHWR). The three stages are being implemented sequentially to reach the goal of large scale thorium utilization and are linked through their respective fuel cycles which are also well underway.

Kaiga-3 (a 220 MWe PHWR) which achieved its first criticality on 26th February, 2007 within 5 years from the first pour of concrete, was synchronized to the grid on 11th April, 2007 and started commercial operations on 6th May, 2007. With completion of Kaiga-3, there are now 17 nuclear power reactors in operation, the total installed capacity being 4120 MWe. The Indian nuclear power sector has achieved over 270 reactor years of safe, accident-free operations. Major ageing management activities including Enmasse Coolant Channel Replacement (EMCCR) were completed in NAPS-1 and the reactor is expected to come back on-line shortly. With this, four PHWRs (RAPS-2, MAPS-1&2, NAPS-1) now have their coolant channels replaced.

The first cycle of Peer-reviews of all the operating stations by WANO has been completed. RAPP-5 unit has also undergone a Pre-Startup Peer Review by an expert team of WANO. This was the second review of its kind in India after TAPP-3; which was reviewed last year. The next Biennial General Meeting (BGM) of WANO will be hosted by India, in 2010 at New Delhi .

Construction activities are underway in full swing at six other reactors – three PHWRs, two LWRs and a 500 MWe PFBR. Of these, two reactors (RAPP-5 and Kaiga-4) would see start of fuel loading during the year. On completion of the reactors currently under construction, there will be 23 reactors in operation with installed capacity of 7280 MWe. The detailed design and engineering of the indigenous 700 MWe PHWR is progressing according to the set time schedule. The Government has given in-principle approval for setting-up of 4x700 MWe PHWRs at two sites and 4x1000 MWe LWRs at another two sites in the country. Establishment of a new Uranium mine and mill at Tummelepalle has also been approved by the Government.

For accelerating the growth of the fast reactors in the country, development of metallic fuel, which would offer high breeding capabilities is being carried out on priority with the aim of its deployment around the year 2020. The next four fast reactors after the PFBR, which are proposed to be commissioned by 2020 will however, continue to use oxide fuel. These future reactors will incorporate refinements in the design and construction, to achieve reduction in capital as well as operational costs, on the basis of experience with the PFBR. The objective is to bring down the unit energy cost substantially as compared to PFBR. Enhancement of the burn-up of the fuel from the present target of 100 GWd/t to 200 GWd/t is recognized as an important step for reduction in the fuel cycle cost. Towards achieving

this target, the development of advanced cladding and structural materials including the oxide dispersion strengthened alloy have been initiated. The expertise generated and the experience gained in this development process will be further harnessed for developing structural materials for the Test Blanket Module being developed by the Institute of Plasma Research as part of the fusion energy programme.

Towards closing the fuel cycle of PFBR, a Fast Reactor Fuel Cycle Facility (FRFCF) has been planned with its construction to commence next year. The facility is expected to be operational, in time to process the irradiated fuel discharged from the PFBR. The production of the mixed oxide fuel for PFBR has already commenced.

I had mentioned in my last year's address in this Conference about excellent performance of our indigenously designed mixed carbide fuel for FBTR and about our successful reprocessing of the high burn-up carbide fuel from FBTR after a short cooling period. I am happy to inform that fissile material recovered from reprocessing has now been fabricated into mixed carbide fuel. This fuel will be loaded into FBTR during the next reload schedule. Closing the mixed carbide fuel cycle has been an important milestone for us in our fuel cycle activities related to fast reactor program. I may also add here that we are now operating FBTR with an expanded hybrid core consisting of mixed carbide and mixed oxide fuel. The high Pu MOX now forms about 20% of the FBTR core.

Mr. President,

We are looking forward to the possibility of opening up of international civil nuclear cooperation. We expect such cooperation to be sustainable, free from interruptions and consistent with our national policy of closed fuel cycle. With a view to significantly augment nuclear power generation capacity in the near-term through imports, as an additionality to the ongoing indigenous programme, a Site Selection Committee has evaluated coastal sites in the country for the reactors to be set up in a convoy mode.

The initiatives also open up the possibility of export of reactors and services. India today is the only country to have a live technology, design and infrastructure for small PHWRs with a unit capacity of 220 MWe, which have a great potential for export, particularly to countries with small grids wishing to enter nuclear power generation, with relatively modest investments and infrastructure. Given the large manufacturing base and relatively low manufacturing costs, there is also a potential for India becoming a manufacturing hub for equipment and components for the global nuclear industry.

We have been actively pursuing the design and development of Advanced Heavy Water Reactor which will mainly use thorium-based fuel and has several advanced safety features. In fact, this reactor would meet the objectives of a futuristic system that would have to meet higher safety, economics, sustainability, long term radioactive waste minimization and proliferation resistance goals. Pre-licensing safety appraisal of this first-of-a-kind design was completed by the Indian Atomic Energy Regulatory Board. A large Critical Facility for validating reactor physics design of the unique core of the AHWR is under commissioning at BARC. We expect this facility to provide important data that would further improve our understanding of the thorium-based reactors.

In the Compact High Temperature Reactor (CHTR) being designed in India , it will be possible to extend the core life up to a period of fifteen years. A liquid metal natural circulation loop employing Lead Bismuth Eutectic alloy as the coolant has been installed to study the CHTR behaviour. Parallely, designs of 600 MWt High

Temperature Reactor (HTR) for hydrogen production and 5 MWt Multi-purpose Nuclear Power Pack (MNPP) are also currently underway.

India has been exploiting research reactors for basic research, neutron radiography, shielding experiments, testing of reactor components including neutron detectors, trace element analysis, etc. We are currently planning to construct a 30 MWt Multi-Purpose Research Reactor (MPRR) capable of providing a maximum thermal neutron flux of 6.7 x 1014 n/cm2/sec and fast neutron flux of 1.7 x 1014 n/cm2/sec. The new reactor will meet the increasing requirements of high specific activity radio-isotopes and would also provide enhanced facilities for basic research in frontier areas of science and for applied research related to development and testing of nuclear fuel and reactor materials. Further, the reactor will have features to enable its conversion to an Accelerator Driven System at a later date.

The superconducting heavy ion LINAC project has reached a major milestone in July 2007 with all seven accelerator modules energized to accelerate 28Si beam to an energy of 209 MeV, highest achieved so far in the country.

We have indigenously developed another supercomputer named ANUPAM-AJEYA which has attained a sustained speed of 3.70 Teraflops, twice that of the speed of its earlier version ANUPAM-AMEYA system. The new system comprises 256 dual-core, dual CPU computing nodes, each processor running at 2.66 GHZ with 4 GByte of main memory. The system will be upgraded shortly to achieve speed exceeding 4 Teraflops.

Our contributions in the area of nuclear agriculture, biology and health have always been significant. As of now, 29 crop varieties have been gazette notified by the Ministry of Agriculture, Government of India for commercial cultivation in the country. For processing of biodegradable waste, 14 indigenously developed Nisargruna biogas plants have been set up in the country so far. On April 26, 2007, KRUSHAK Irradiator at Lasalgaon in the State of Maharashtra became the first Cobalt-60 gamma irradiation facility to be certified by the United States Department of Agriculture-Animal & Plant Health Inspection Service (USDA-APHIS) for phytosanitary treatment of mangoes. Consequently, this year, the facility enabled export of 157 tons of mangoes, mainly of Alphonso and Kesar varieties, to the United States of America , after a gap of 18 years.

As in the past, we have been closely interacting with the Agency as partners in development. India was one of the founder members and a strong supporter of INPRO. We have noted with great satisfaction the progress made in this important activity of the Agency. In particular, the recent step to initiate, under Phase-2 of INPRO, several collaborative projects under Joint Initiative mode has a great potential to facilitate cost effective development of solutions relevant for global deployment of next generation advanced nuclear energy systems. We once again stress the need to provide full budgetary support to the INPRO activities, recognizing its immense potential to lead to global enhancement in the availability of safe and economical nuclear energy to meet the future demands.

In the area of Nuclear Security & Physical protection, India along with IAEA has been organizing workshops/ training courses for the Asia & Pacific region and serves as Regional Resource Centre. So far, we have conducted four Regional Training Courses on Physical Protection of Nuclear installations and also a Regional Training Course on the Physical Protection of Radioactive Sources. In addition, we have conducted Regional Training Courses on Advanced Detection Equipment and on Response to criminal or unauthorized acts involving nuclear or other radioactive material and also a Regulatory Authority Information System (RAIS) Training Course. We are about to deposit our instrument of ratification to the amendment to the CPPNM.

Mr. President,

Global nuclear energy renaissance which has become a necessity and appears to be well on cards, however, rests today on a very fragile foundation. We need to build robust inclusive partnerships on an objective, reliable and predictable basis with a holistic mutual understanding and trust. The need to adopt fuel recycle to maximize energy availability makes it even more necessary. We are all justifiably concerned about the risks related to safety, environment and proliferation arising out of irresponsible behaviour of state and non-state actors. However, we need to be even more concerned about the vastly enhanced security risk to which future generations would be exposed as a result of direct disposal of spent fuel leading to plutonium mines when a large part of radioactivity decays. There are, thus, risks and challenges. But they are within the professional competence of nuclear energy community. A judicious combination of technology and institutional control with every responsible partner being a part of the solution, rather than being seen as a problem, can in fact provide the answer.

Thank you, Mr. President."

ANNOUNCEMENT

Forthcoming Symposium

Symposium on Emerging Trends in Separation Science & Technology SESTEC – 2008

DAE/BRNS has organized a three-day symposium from March 12-14, 2008, at the Dept. of Chemistry, Univ. of Delhi, Delhi. It will provide a platform to scientists and engineers to discuss recent advances in the area of separation of metals, particularly the lanthanides, the actinides and the platinum group metals. These are of great interest to DAE and its ongoing programmes on the areas of nuclear fuel cycle and production of isotopes.

The scientific programme of the symposium will include invited talks and contributory posters/ papers on the following topics: 1) Design, synthesis and characterization of solvents, resins of membranes 2) Design and development of separation equipment 3) Separation science & technology in the nuclear fuel cycle 4) Emerging separation technologies 5) Electrochemical and pyrochemical separations 6) Treatment of Industrial effluents 7) Isotope separations 8) Membrane/ Chromatographic separations 9) Radiochemical separations and 10) Separation of enantiomers/ polymorphs.

For accommodation at Delhi, requests may be addressed before 10th Feb. 2008 to

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बी एआरसी न्यूज़लैटर
BARC NEWSLETTER

THEME MEETING ON "ADVANCES IN REACTOR PHYSICS : DESIGN, ANALYSIS AND OPERATION OF NUCLEAR REACTORS"

Reactor Physics plays a major role in the design and safe operation of nuclear reactors. DAE is embarking on several new projects, like the VVER, advanced 700 MWe PHWR, a Prototype Fast Breeder Reactor (PFBR) and large scale thorium utilisation by way of an Advanced Heavy Water Reactor (AHWR). The physics of these reactor types encompasses a wide spectrum of various fields of Reactor Physics. It was appropriate that at this juncture a theme meeting on "Advances in Reactor Physics - Design, Analysis and Operation of Nuclear Reactors" was organized by RPDD during May 24 - 25, 2007. This meeting was held in the multipurpose hall of TSH, Anushaktinagar and was attended by 170 nominated participants from BARC, IGCAR, AERB, NPCIL, SRI-AERB and a few ex-scientists of BARC. The participants were also from different fields apart from Reactor Physics.

The Chairman, AEC, inaugurated the meeting. Director BARC and Director (T), NPCIL also addressed the delegates. The Chairman spoke about the challenges

On the dais from left to right are: Mr. S.A. Bharadwaj, Director(T), NPCIL, Dr S. Banerjee, Director, BARC and Dr Anil Kakodkar, Chairman, AEC

Dr Anil Kakodkar, Chairman, AEC delivering the talk

Reactor Physicists have to face in designing new energy systems. Director BARC spoke about the bond between Physics of matter and Reactor Physics and emphasized the need for a cohesive effort, on the indigenous development of neutronics codes. He summarized several achievements in Reactor physics over the years. Mr. S.A. Bharadwaj Director(T), NPCIL stressed the role of Reactor Physics in the operation and safety of nuclear power plants.

The meeting was organized in seven technical sessions and a poster session. The technical sessions were on Fast Reactor Physics, Heavy Water and Light Water Physics, Innovative Reactor Concepts like HTR and ADS, AHWR, Advances in PHWR and Research reactors, Experimental Physics, Advanced Analysis Methods, Operational Reactor Physics, Safety and Regulatory aspects of nuclear reactors.

The two–day meeting was very well attended. Twenty-one young scientists were invited to speak on various topics on the above subjects. We had also invited contributions in the form of posters. All the talks were very well received and the discussions were interactive. There were 32 poster papers from various units of DAE. Five papers were selected for a cash award of Rs. 1000/- each.

The Chairman AEC, also gave an evening talk on 24th May, 2007, where he discussed the close interaction between Reactor Physics and engineering in reactor design. He also spoke about the challenges faced in typical projects. He encouraged the delegates to indulge in brainstorming sessions on new concepts and look into various energy domains and innovations, which would be exciting for researchers.

The meeting concluded with a panel discussion chaired by Mr. S.S Bajaj, Sr. Exec. Dir. (Safety), NPCIL and other members Dr R. Srivenkatesan, Head, RPDD, Dr S.K. Gupta, AERB, Dr S.V. G. Menon, Head, ThPD, Dr K.P.N. Murthy, Univ. of Hyderabad.

From left to right are; Dr S.K. Gupta, AERB, Dr R. Srivenkatesan, Head, RPDD, Mr. S.S Bajaj, Senior Executive, Director (Safety) NPCIL, Dr S.V.G. Menon, Head,ThPD, Dr K.P.N. Murthy, Univ. of Hyderabad,

Among the several concrete suggestions which emerged during the meeting a few of them were:

1. Focus on indigenous code development (3D Coupled Neutronics-Thermal Hydraulics code, Monte Carlo code for neutron transport etc.).

2. Formation of a forum for Reactor Physics on a national level.

3. Cater to the nuclear data requirement for thorium based systems, HTRs and ADSS (which will require international collaborations as well).

4. Identify generic problems with regards to operation and safety.

5. Code depository: Professionalism in code development ; documentation of existing codes is immediately required.

   It was strongly felt that codes should be shared and kept in a common place, regularly updated and validated. This kind of professional approach would avoid duplication.

6. Arrange training courses / workshops on specific topics (eg., Space-time kinetics, Transport Theory).
7. Develop a new approach towards Regulatory aspects of Reactor Physics Design and safety especially for newer systems.
8. Validate designs through experimental measurement and analysis (plan more experiments in Research/Power reactors).

The meeting focussed on challenges for the future, improvements in reactor analysis, robust designs, state-of-the–art capabilities for design tools and supportive experiments. This meeting brought together many experts and fresh talent in the specialized discipline of Reactor Physics.

THEME MEETING ON RADIATION HOT SPOT MANAGEMENT IN INDIAN NUCLEAR POWER PLANTS

The Health Physics Division, BARC, had organized a theme meeting on Radiation Hot Spot Management in Indian Nuclear Power Plants during August 9 and 10, 2007 at Nuclear Training Centre, Tarapur Atomic Power Stations 3&4.

There were 33 case study presentations during the theme meeting. Case studies were related to identification of radiation hot spots, gamma spectrometry of the hot spots to assess the radionuclides contributing to the hot spots, measures incorporated to manage the hot spots to control exposures to plant personnel in the work environment. The presentations included shielding aspects of the hot spots to reduce the ambient dose rates in the work areas. Good practices followed in nuclear power plants related to management of these hot spots such as flushing of the lines, equipment, fueling machine parts, chemical decontamination of the system and equipment and cutting and removal of the piping, removal and replacement of the active equipment etc. were discussed with illustrations.

Presentations included photographs of the locations and the effects of dose rate control measures adopted and the saving of station collective dose. WANO good practices related to requirement and industry practices, with regard to shield control aspects were also discussed.

About 80 persons participated in the theme meeting. Participants included members from health physics units, fuel handling sections, operation and maintenance sections from different nuclear power plants and specialists from Health, Safety, Environment and Public Awareness Group NPCIL and Health Safety and Environment Group, BARC. The meeting provided an opportunity for radiation protection professionals, operation and maintenance personnel to share the intricacies in managing the radiation sources in work places and exposures to plant personnel.

The meeting was inaugurated by Mr. O.P. Goyal, Site Director, Tarapur, Maharashtra Site.

The meeting was useful in identifying all sources of radiation hot spots and the effect of material selection for the piping and equipment in work areas in nuclear power plants. The presentations brought out the need to eliminate Antimony, Cobalt and Zinc in the construction materials and in the seals and valve seats in nuclear power plants.

The feedback from the participants and other information was compiled and communicated to the nuclear power plant designers. The information will aid the designers to incorporate suitable changes in the material selection, equipment installation and construction aspects. These changes will be useful to achieve ALARA exposures to the plant personnel in Indian nuclear power plants and to meet the industry standards in the years to come.

बीएआरसी न्यूज़लैटर
BARC NEWSLETTER

TWO DECADES OF QUALITY CIRCLES: BENEFITS OF INNOVATIVE APPROACH IN THE FIELD OF RADIATION PROTECTION IN INDIAN NUCLEAR POWER PLANTS

Team work plays an important role in any organization to promote the productivity of the persons involved in manufacturing or services. The Japanese had utilized this feature in their organizations and reaped rich dividends in terms of excellent product quality and in service sectors like banking, medical service and education. Several problem-solving techniques which include processing of numerical data as well as language data are in use in Japanese industries. These include techniques like 7 statistical tools, work place management popularly known as Five S, Deming Circle, Poka Yoke, Kanban, Affinity diagram, Relation diagram, Cause and Effect diagram etc. The Quality Circles which comprise of volunteers from the field, brought in innovative approach in every walk of life and strengthened the nation's economy. Quality Circle concept came to India during 1982 through BHEL, Hyderabad. To day the quality culture had spread to several industries and service sectors in India.

Quality circles were introduced to Nuclear Power plants during 1987. The Health Physics Division had recognized the potential of the Quality Circles and made efforts to promote team work to bring out the potential of the plant personnel and health physics personnel to improve safety in a cost-effective manner in all the nuclear power plants. About 150 Quality Circles are functioning in different nuclear power stations in our country.

These circles had prepared and presented about 450 case studies during the last two decades. Health physics units in different power stations actively participated in spear heading quality approach in power stations through organization of regular training programs on problem solving techniques and also developed several systems and modifications to enhance the efficiency of radiation production groups in the power stations. As of now about 15 Quality Circles are functioning in health physics units and more than 80 case studies were presented by these circles in different fora. The circle activities supported by the plant management resulted in saving of money, manrem and man-hours. Development of innovative radiological information and communication systems and knowledge management were the benefits of these continuous improvement efforts. Some of the important developmental work carried out in the power stations by the health physics teams follows:

Case studies from TAPS 1&2

Avakash QC:

01. Enhancement in Thermo-Luminescent Dosimeter Issue Program
02. Quality improvements in maintenance of outside plant areas
03. Application of area radiation monitor in radiography tests
04. Use of 3D animations for pre job briefing, mock ups and on-the-job training
05. Process development of radioactive waste storage tanks.

Avishkar QC:

01. Measures adopted in collective dose reduction
02. Tools to reduce lost time in execution of jobs in radioactive areas.
03. Analysis of operating experience and revision of

set points for area radiation monitors.

04. Development of database for health physics instruments
05. Evolution of budget code for effective dose control.

Case studies from TAPS 3&4

Dream QC:

01. Development of Dose Management Software
02. Development of Software for Health Physics Data Management
03. Development of radiation instrument calibration facility
04. Development of Dose info.com
05. Implementation of Five S in health physics unit laboratories.

Cosmos QC:

01. Development of Radiation protection training facility
02. Development of Handy air samplers
03. KAIZEN in gaseous effluent monitoring system
04. Development of model hand and foot contamination monitors
05. Range extension of low range area radiation monitors.

Case studies from MAPS 1&2

Radiation Safety QC:

01. Development of Hydrostatic absorption sampling system for tritium estimation
02. Quick assessment of particulate activity by survey of filter paper
03. Development of health physics sampling stations in reactor building areas
04. Standardization of remote sampling technique for air activity estimation
05. Assessment of particulate air activity by gravity settling technique
06. Development of cartridge syringe system for estimation of fission product noble gases and radio iodine in reactor building environment.
07. Development of PVC bubblers for assessment of tritium in air
08. Resolving the dose differences in dosimetry devices (thermo-luminescent dosimeter and direct reading dosimeter)
09. Improvement in tritium in air assessment technique from remote areas (fuel transfer room, shut down accessible areas)
10. Development of air displacement system for tritium in air assessment in reactor building environment
11. Minimizing the difficulties in issue and collection of direct reading dosimeters
12. Minimizing the difficulties in issue and collection of thermo-luminescent dosimeters
13. Stream lining the issue of thermo-luminescent dosimeters for contractor personnel
14. Quality Assurance in tritium assessment techniques
15. Improvements in public awareness programs for members of public in emergency planning zone
16. Improvement in availability of direct reading dosimeters during reactor outages
17. Up linking of tritium uptake data to shift room for radiological work permit clearance.

Source QC:

01. Development of teledosimetry for monitoring work in shut down accessible areas
02. Development of dosimeter calibration system
03. Development of system for floor contamination monitoring.

Model QC:

01. Introduction of plastic vials for tritium assessment in the laboratory
02. Minimizing the difficulties in clearing radiological

work permits

03. Improving dose planning to reduce unplanned exposures
04. Work place management in health physics unit laboratories.
05. Development of an apparatus (PAVITRA) to decontaminate plastic vials
06. Optimization of cost of scintillation cocktail
07. Minimizing the maintenance requirement for teletectors
08. Conservation of compute stationary (all sections)
09. Improvements in radiation protection training (Pre job briefs, JIT briefs, SOERs)
10. Improvements in radiation protection training to plant personnel
11. Development of techniques to reduce radioactive wastes
12. Development of barcode system for issue/ collection of direct reading dosimeters
13. Development of software for online radiological work permit clearance
14. Development of radiation protection information system.

Case studies from KAPS 1&2

Health Physics QC:

01. Development of Tritium air sampler (two bubbler system)
02. Tritium air sampling through gravity flow device

Rising Sun QC:

01. Development of software to monitor bioassay sample submission compliance.

ANNOUNCEMENT

Forthcoming Symposium

Sixteenth National Symposium & Workshop on Thermal Analysis

THERMANS 2008

DAE/BRNS has organized a three-day symposium from Feb. 4-6, 2008, and a two day Workshop from Feb. 7-8, 2008, at the Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamilnadu.

The following topics would be covered:
1) High temperature thermochemistry and phase equilibrium studies 2) Thermochemical and thermophysical properties of nuclear materials 3) Solid state reactions and kinetics 4) Novel materials such as conducting polymers, ionic liquids 5) Nanomaterials 6) Polymers, composites and high energy materials 7) Glass and ceramics 8) Catalysts 9) Bio-materials 10) Molten salts and 11) Phase diagram computations and modeling.

For details regarding submission of abstracts; Participation in M.D. Karkhanawala Essay Contest 2008; NETZSCH-ITAS Award 2008; TA Instruments - ITAS Young Scientist Award 2008; Dr Gurdip Singh Award for Best Thesis in Thermal Analysis; one can visit the website **www.itasindia.org**

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

''न्यूट्रान डोज़ इवैल्यूएशन फ्रॉम ए 15 MV इंडस्ट्रियल एक्सेलरेटर'', नामक लेख को अंतर-विश्वविद्यालय त्वरक केंद्र (आईयूएसी), नई दिल्ली में दिनांक 26-27 अप्रैल, 2007 के दौरान आयोजित ''एक्सेलरेटर एण्ड लो लेवल रेडियेशन सेफ्टी'' सम्मेलन में पोस्टर प्रस्तुतीकरण के दौरान उत्कृष्ट लेख का पुरस्कार प्रदान किया गया। इस लेख के लेखक आर.के.यादव (आरपीएडी), वी.सतियन (आरएसएसडी), आर.कन्नन (आरपीएडी) एवं यू.वी. फडणीस (आरएसएसडी) हैं ।

A paper entitled "Neutron Dose Evaluation from a 15 MV Industrial Linear Accelerator", authored by R.K.Yadav (RPAD), V.Sathian (RSSD), R.Kannan (RPAD) and U.V. Phadnis (RSSD) was adjudged the Best paper in the poster presentation category at the Conference on "Accelerator and Low Level Radiation Safety" held at Inter-University Accelerator Centre (IUAC), New Delhi during 26-27 April, 2007. Mr. R.K.Yadav had presented the paper.


R.K.Yadav

श्री आर.के.यादव ने आर. ई. सी. राउरकेला से भौतिकी में एम.एससी के पश्चात मुंबई विश्वविद्यालय से विकिरणकीय भौतिकी में डिप्लोमा पाठ्यक्रम पूरा किया । वे वर्ष 1997 में भापअ केंद्र के आरपीएडी में शामिल हुए । वे विकिरण के विभिन्न औद्योगिक अनुप्रयोगों के विकिरणकीय संरक्षा पहलुओं पर कार्य कर रहे हैं। वे भारत में औद्योगिक रेडियोग्राफी के शील्डिंग मूल्यांकन औद्योगिक किरणक एवं त्वरक सुविधाओं के साथ जुड़े हुए हैं। वे गुणवत्ता आश्वासन एवं औद्योगिक त्वरकों के कमीशन पूर्व परीक्षण, एक्स-रे मशीन एवं गामा रेडियोग्राफी उपस्कर/सह सामग्रियों के साथ भी जुड़े हैं । वे भापअ केंद्र द्वारा आयोजित विभिन्न अल्पावधि एवं एक वर्षीय प्रशिक्षण कार्यक्रमों हेतु फैकल्टी सदस्य के रूप में कार्यरत हैं। डिजिटल रेडियोग्राफी एवं उच्च-ऊर्जा त्वरकों में विकिरणकीय संरक्षा उनकी अभिरुचि के क्षेत्र हैं ।

Mr. R.K.Yadav completed his M.Sc. in Physics from R.E.C. Rourkela and Post-M.Sc. Diploma course in Radiological Physics from Mumbai University. He joined RPAD in 1997. He is working on the radiological safety aspects of various industrial applications of radiation. He is associated with shielding evaluation of industrial radiography, industrial irradiator and accelerator facilities in India. Also, he is associated with quality assurance and pre-commissioning test of industrial accelerators, X-ray machines and gamma radiography equipment/accessories. He serves as a faculty member for various short-term and one-year training programs conducted by BARC. His field of interest is digital radiography and radiological safety in high-energy accelerators.


V. Sathian

श्री वी.सतियन ने कैलिकट विश्वविद्यालय से नाभिकीय भौतिकी में एम.एससी के पश्चात मुंबई विश्वविद्यालय से विकिरणकीय भौतिकी में पोस्ट एम.एससी डिप्लोमा पाठ्यक्रम पूरा किया । उन्होंने वर्ष 1993 में भापअ केंद्र में कार्यग्रहण किया एवं वर्तमान में भापअ केंद्र के आरएसएसडी में कार्यरत हैं । वे न्यूट्रान उत्पाद एवं फ्लूएन्स दर मापन हेतु प्राथमिक एवं द्वितीयक मानकों के विकास से जुड़े हैं । वे रिएक्टर के नियामक एवं संरक्षा वाहकों में प्रयुक्त न्यूट्रान संसूचकों के परीक्षण के साथ भी जुड़े हैं । त्वरक एवं रिएक्टर पर्यावरण में न्यूट्रान फील्ड मानवीकरण, न्यूट्रान वर्णक्रममिति एवं न्यूट्रान मात्रामिति उनकी अभिरुचि के क्षेत्र हैं ।

Mr. V. Sathian completed his M.Sc. in Nuclear Physics from Calicut University and Post-M.Sc. Diploma course in Radiological Physics from Mumbai University. He joined BARC in 1993 and is presently working in RSSD. He is associated with development of primary and secondary standards for the neutron yield and fluence

rate measurement. Also, he is associated with the testing of neutron detectors used in regulatory and protection channels of reactors. His field of interest is neutron field standardization in accelerator and reactor environment, neutron spectrometry and neutron dosimetry.


R. Kannan

श्री आर. कन्नन ने वर्ष 1970 में भापअ केंद्र में कार्यग्रहण किया । प्रारंभ से ही वे विकिरणों के चिकित्सीय एवं औद्योगिक अनुप्रयोग की विकिरण संरक्षा के पहलू से जुड़े रहे । वे गुणवत्ता आश्वासन एवं औद्योगिक त्वरकों के कमीशनन पूर्व परीक्षण, एक्स-रे मशीन एवं गामा रेडियोग्राफी उपस्कर/सह सामग्रियों के साथ जुड़े हुए हैं । वर्तमान में वे विकिरणकीय प्रशिक्षण अनुभाग के प्रभारी अधिकारी हैं एवं विभिन्न अल्पकालीन एवं दीर्घकालीन प्रशिक्षण कार्यक्रम के लिए उत्तरदायी हैं ।

Mr. R. Kannan joined BARC in 1970. Since the very beginning he is associated with radiological safety aspect of medical and industrial application of radiations. His field of specialization is radiation protection, radiation emergency handling and quality assurance in industrial radiography. He is associated with quality assurance and pre-commissioning test of industrial accelerators, X-ray machines and gamma radiography equipment/ accessories. Presently he is officer-in-charge of the radiological training section and responsible for various short-term and long-term training programmes.


U.V. Phadnis

श्री यू.वी.फडणीस ने वर्ष 1970 में इंदौर विश्वविद्यालय से भौतिकी में एम.एससी एवं प्रशिक्षण विद्यालय के 14वें सत्र से स्नातक बनने के पश्चात उन्होंने भापअ केंद्र में कार्यग्रहण किया। पिछले 35 वर्षों से वे न्यूट्रान उत्पाद एवं न्यूट्रान फ्लूयेन्स दर मापन हेतु प्राथमिक एवं द्वितीयक मानकों के विकास एवं अनुरक्षण के उत्तरदायी हैं । हाल ही में उनके दल द्वारा विभिन्न प्रकार के न्यूट्रान मानीटरों के अंशांकन हेतु आईएसओ संस्तुत न्यूट्रान स्रोत मानकों का विकास किया गया । उनके वर्ग द्वारा विकसित मानक भारत के पऊ वि एवं गैर-पऊवि संस्थानों में प्रयोग में लाए जा रहे हैं । फाइल सक्रियण तकनीकों के प्रयोग द्वारा विभिन्न रिएक्टर एवं त्वरक स्थानों में न्यूट्रान फ्लूयेन्स दरों का मापन इनकी अभिरुचि के क्षेत्र में शामिल हैं ।

Mr. U.V. Phadnis completed his M.Sc. in Physics from Indore University in 1970. After graduating from 14th batch of Training School, he joined BARC. Currently he is leading Neutrons Standards Group of Radiation Standards Section of RSSD. He is responsible for developing and maintaining primary and secondary standards for neutron yield and neutron fluence rate measurements, for the last 35 years. Recently, his group developed ISO recommended Neutron Source Standards for calibration of various types of neutron monitors. Standards developed by his group are widely used both in DAE and non-DAE institutions in India. His field of interest includes measurement of neutron fluence rates at various reactor and accelerator locations using foil activation techniques.

भापअ केंद्र में दिनांक 8-10 मार्च, 2007 के दौरान भौतिकी एवं सेंसरों की प्रौद्योगिकी पर आयोजित राष्ट्रीय संगोष्ठी में "टैल्यूरिम तनु फिल्म आधारित गैस सेंसर" विषय पर प्रस्तुत पेपर के लिये सर्वोत्कृष्ट पोस्टर पुरस्कार प्रदान किया गया । इस पेपर के लेखक टीपीपीईडी के डॉ. (कु.) एस. सेन, श्री वी.भंडारकर , श्री के.पी.मुठे, श्री एस.के.गुप्ता एवं श्री जे.वी.याख्मी थे ।

Best Poster Award was given for the paper "Tellurium Thin films based gas sensor" presented at the National Seminar on Physics & Technology of Sensors, held at BARC from March 8-10, 2007. The authors of this paper were (Ms) S. Sen Mr. V. Bhandarkar, Mr. K.P. Muthe, Mr. S.K. Gupta and Dr. J.V. Yakhmi of TPPED.

डॉ.शाश्वती सेन ने वर्ष 1996 में प्रशिक्षण विद्यालय के 40वें सत्र द्वारा भापअ केंद्र में सेवा में प्रवेश किया । उन्होंने "डिस्सिपेशन मैकेनिज्म इन हाई टेंपरेचर सुपरकंडक्टर्स" पर किये गये उनके कार्य के लिये वर्ष 2003 में मुंबई विश्वविद्यालय से


S. Sen

पीएचडी उपाधि प्राप्त की । वर्तमान में वह तात्विक एवं धातु आक्साइड अर्धचालक तनु फिल्मों एव नैनों संरचनाओं पर आधारित गैस सेंसरों पर कार्य कर रही हैं ।

Dr (Ms) Shashwati Sen joined BARC in 1996 through the 40th batch of training school. She obtained her PhD degree from Mumbai University in 2003 for her work on "Dissipation mechanism in high temperature superconductors". Currently she is working on gas sensors based on elemental and metal oxide semiconductor thin films and nano structures.


K.P. Muthe

श्री के.पी.मुठे थिन फिल्म के विकास एवं अभिलक्षणन के क्षेत्र में कार्य कर रहे हैं। उन्होंने एमबीई का प्रयोग करते हुए एचटीएससी की वृद्धि व्यवहार का अध्ययन किया है । उनके इस कार्य ने उन्हें मार्क्विस की जीवनी-वार्षिकी (1997) एवं इंटरनैशनल बायोग्राफी शब्दकोश में स्थान दिलाया है । संक्षरण एवं गैस डिटेक्शन की मेकेनिज्म जैसी पदार्थ संबंधी अनेक समस्यायों के समाधान के लिए एक्स-रे फोटोइलेक्ट्रान स्पेक्ट्रोस्कोपी का विस्तृत प्रयोग किया है एवं लगभग 50 प्रकाशनों में अपना योगदान दिया है । कार्मिक मात्रामिति हेतु विषैली गैस संसूचन एवं एल्यूमिना आधारित विकिरण सेंसरों के संश्लेषण जैसे कार्यों में उनकी विशेष अभिरूचि रही है । वे प्रशिक्षण विद्यालय के 30वें बैच के हैं ।

Mr. K.P. Muthe is working in the field of thin film growth and characterization. He has studied the growth behavior of HTSC films using MBE. The reference value of this work has fetched him a place in Marquis Who's Who of the world (1997) and Dictionary of International Biography (1999). He has extensively used X-Ray photoelectron spectroscopy to solve several material-related problems like corrosion and mechanisms of gas detection and contributed to around 50 publications. His interests also include toxic gas detection and synthesis of Alumina based radiation sensors for personnel dosimetry. He belongs to the 30th batch of Training School.


S.K. Gupta

डॉ. एस.के.गुप्ता ने भौतिकी में एक वर्ष का ओरियंटेशन पाठ्यक्रम समाप्त करने के पश्चात वर्ष 1975 में भापअ केंद्र में कार्यग्रहण किया । वर्तमान में वे भापअ केंद्र के तकनीकी भौतिकी एवं आदिप्रारूप इंजीनियरी प्रभाग के थिन फिल्म डिवाइसेस अनुभाग एवं अनुप्रयुक्त अतिचालकता एवं क्रायोजेनिक्स अनुभाग के अध्यक्ष हैं । पिछले कुछ वर्षों से वे अंतरिक्ष के गुणवत्ता वाले सिलिकान सोलार सेल्स, उच्च टीसी अतिचालकों के ऐपीटैक्सीय तनु फिल्म तैयार करने, अतिचालकों में जलावर्त गतिकी पर अध्ययन एवं अर्धचालक थिन फिल्म आधारित H_2S एवं H_2 गैस सेंसरों आदि के विकास कार्य से जुड़े हैं । वर्तमान में वे कलोजल मैग्नेटोरेजिस्टन्स (सीएमआर) थिन फिल्म, सीएमआर/अर्धचालक तिचाले जंक्शन एवं अर्धचालक तथा पालीमर आधारित गैस सेंसरों का अध्ययन कर रहे हैं । उन्होंने वर्ष 1980 में सौर ऊर्जा हेतु "श्री हरि ओम आश्रम प्रेरित एस. एस.भटनागर पुरस्कार" संयुक्त रूप से प्राप्त किया और वर्ष 1992-93 के दौरान उन्हें " इंडो-यूएस फेलोशिप इन साइन्स एण्ड टेक्नालाजी " का पुरस्कार प्रदान किया गया । अंतरराष्ट्रीय पत्रिकाओं में उनके 80 लेखों का प्रकाशन हुआ है और वे भारतीय राष्ट्रीय विज्ञान अकादमी के सदस्य हैं ।

Dr S. K. Gupta joined Bhabha Atomic Research Centre as Scientific Officer in the year 1975 after completing one year orientation course in Physics. Presently he is Head of Thin Film Devices Section and Applied Superconductivity & Cryogenics Section in Technical Physics & Prototype Engineering Division of BARC. Over the years he has been involved in the development of Space quality silicon solar cells, preparation of epitaxial thin films of high Tc superconductors, studies on vortex dynamics in superconductors and development of semiconductor thin film based H_2S and H_2 gas sensors etc. Presently he is involved in studies on colossal

magnetoresistance (CMR) thin films, CMR/superconductor junctions and development of semiconductor and polymer-based gas sensors. He shared the "Shri Hari Om Ashram Prerit SS Bhatnagar Award" for solar energy in the year 1980 and was awarded "Indo-US fellowship in Science and Technology" during the year 1992-93. He has published 80 papers in international journals and is a member of the National Academy of Sciences, India.


J.V. Yakhmi

डॉ. जे.वी. याख्मी, सह निदेशक (एस), भौतिकी वर्ग एवं अध्यक्ष, तकनीकी भौतिकी तथा आदिप्रारूप इंजीनियरी प्रभाग, भापअ केंद्र ने पिछले 40 वर्षों के दौरान पदार्थ विज्ञान में अनुसंधान के विविध क्षेत्रों यथा उच्च टीसी प्रणालियों चुंबकीय मिश्रधातु, आण्विक पदार्थ आदि में कार्य किया है । वे अनेक राष्ट्रीय एवं अंतरराष्ट्रीय पुरस्कार/फेलोशिप प्राप्त कर चुके हैं । वे राष्ट्रीय विज्ञान अकादमी; महाराष्ट्र विज्ञान अकादमी के सदस्य हैं एवं एशिया पैसिफिक अकादमी ऑफ मटीरियल्स के निर्वाचित सदस्य है; उन्हें "यूडीसीटी गोल्डन जुबली विजिटिंग फेलो", मुंबई विश्वविद्यालय, 1997; एमआरएसआई-आईसीएससी अतिचालकता एवं पदार्थ विज्ञान पुरस्कार 1995 पुरस्कार भारतीय पदार्थ विज्ञान संस्था द्वारा प्रदान किया गया उन्हें कुरुक्षेत्र विश्वविद्यालय से वर्ष 1996 में उत्कृष्ट स्नातक पुरस्कार; औद्योगिक विज्ञान संस्थान, टोकियो, विश्वविद्यालय से वर्ष 1996 में आई आई एस स्वर्ण पदक ; भारत फ्रांस परियोजना 1308-4 की वैज्ञानिक परिषद सी ई एफ आई पी आर ए द्वारा "आण्विक पदार्थों की रासायनिकी तथा भौतिकी" पर 1996-99 के दौरान " उत्कृष्ठता " पुरस्कार दिया गया । उन्होंने " थैलियम आधारित उच्च ताप वाले अर्धचालक नामक पुस्तक का सह संपादन किया है एवं 300 से भी अधिक वैज्ञानिक प्रकाशनों का लेखक कार्य किया है ।

Dr. J.V. Yakhmi, Associate Director (S), Physics Group and Head, Technical Physics and Prototype Engineering Division of BARC, has worked for the past 40 years on diverse areas of research in materials science such as, high Tc systems, magnetic alloys, molecular materials etc. He is the recipient of several national and international awards/fellowships. He is a Fellow, National Academy of Sciences, India; Maharashtra Academy of Sciences; Elected Member, Asia Pacific Academy of Materials; he received "UDCT Golden Jubilee Visiting Fellow" and University of Bombay, 1997 honours; MRSI-ICSC Superconductivity and Materials Science Prize 1995 instituted by the Materials Res. Soc. of India; Distinguished Alumni Award from Kurukshetra University (India) 1996; IIS Gold Medal of the Institute of Industrial Science, University of Tokyo, 1996; Award of 'Excellence' by the CEFIPRA Scientific Council to the Indo-French Project 1308-4 "Chemistry and Physics of Molecular-based Materials" carried out during 1996-99. He has coedited a book entitled "Thallium-Based High Temperature Superconductors" and authored more than 300 scientific publications.


Ms. P. Mathi

कु. पी. मैती, लेसर एवं प्लाज्मा प्रौद्योगिकी प्रभाग, भापअ केंद्र ने भारतीय विकिरण एवं प्रकाश रसायन विज्ञान संस्था (आईएसआरएपीएस) द्वारा मद्रास विश्वविद्यालय, चेन्नै में 29-31 जनवरी, 2007 के दौरान विकिरण एवं प्रकाश रसायन विषय पर आयोजित राष्ट्रीय संगोष्ठी में "सल्फर-33 समस्थानिक के लेसर पृथक्करण : एक नवीन द्विचरणीय पहल" शीर्षक वाले शोध-पत्र के लिए सर्वोत्कृष्ट पोस्टर प्रस्तुतीकरण पुरस्कार जीता । इस पुरस्कार के अंतर्गत एक हजार रुपये की नकद राशि एवं एक प्रमाण-पत्र प्रदान किया जाता है ।

Ms. P. B. Mathi, Laser & Plasma Technology Division, won the Best poster presentation award for her paper titled "Laser separation of Sulphur – 33 isotope : a novel two stage approach" presented at the National Symposium on Radiation & Photochemistry organized by the Indian Society for Radiation & Photochemical Sciences (ISRAPS) at the University of Madras, Chennai during January 29–31, 2007. The award carried a cash prize of Rs. 1000/- and a certificate.

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