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TECHNOLOGICAL INNOVATIONS IN DESALINATION

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Introduction

The cost of desalted water depends on three factors, namely, energy input, depreciation and interest, and operation and maintenance cost. Each of the three components contributes roughly one third to the total water cost. The cost of desalted water is coming down due to continued R&D and technological innovations in both thermal and membrane desalination. In the field of thermal desalination, efforts are directed towards utilizing the low grade heat and the waste heat as energy input for desalination, lesser chemical treatment and the advantage of scale up to higher capacity as a cost reduction strategy. In membrane desalination, work is being carried out on newer pretreatment methods like use of ultrafiltration, energy reduction using energy recovery devices and higher membrane life from better quality membranes. Work is pursued on hybrid desalination for producing different quality of product water for process industries and for potable use at lower cost. Table 1 gives the specific capital cost and desalted water cost for seawater desalination for the year 1980-2000. A projection for the year 2010 is also given. It is expected that the specific capital cost of seawater desalination plant will come down in the range of US $ 500-700 / daily m^3 and water cost in the range of US$ 0.5-0.7/m^3 by the year 2010. The cost for brackish water and effluent treatment by membrane processes are known to be even lower.

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Table 1 : Seawater desalination cost

Year	Capital cost (US$/ daily m^3)	Water cost (US$/$m^3$)
1980	1500	1.25
1990	1000-1200	1.0-1.2
2000	800-1000	0.8-1.0
2010	500- 700	0.5-0.7

Milestones Covered So Far

Desalination Division has been engaged in R & D on desalination since 1970s. The desalination activities were part of a programme of setting up a number of demonstration plants for the energy intensive processes such as desalination of sea water, electrolytic production of hydrogen, and electro-thermal production of phosphorus. These activities are presently termed by IAEA as "Non Electrical Application of Nuclear Energy". The activities on desalination in the beginning were based on thermal processes. Later the programme of membrane processes was also included in the 1980s when this process showed commercial viability. Table 2 gives the list of the pilot plants installed and operated/ operating. These plants provided useful design data for larger capacity plants and for bringing in further technological innovations.

Table 2: Pilot plants installed and operated so far

			Date of Commissioning
I.	*Thermal*		
	1.	15 m^3/d MSF experimental facility	1975
	2.	30 m^3/d low temperature evaporation unit	1985
	3.	425 m^3/d MSF plant	1990
	4.	1 m^3/d thermo-compression desalination unit	1997
II.	*Membrane*		
	1.	3 x 30 m^3/d brackish water RO plants providing drinking water in villages of Andhra Pradesh, Gujarat and Rajasthan	1984 (1998 Jodhpur)
	2.	50 m^3/d RO industrial effluent treatment plant at RCF	1986
	3.	15 m^3/d RO-DM plant at VECC for production of low conductivity water	1994
	4.	2 x 10 m^3/d RO units for treatment of radioactive liquid effluents	1990
	5.	24 m^3/d NF plant for a pharmaceutical industry	1998
	6.	40 m^3/d SWRO plant at Trombay being upgraded to 100 m^3/d capacity	1999

Nuclear Desalination

Coupling of 6300 m³/d hybrid MSF-RO plant with PHWR (MAPS, Kalpakkam)

In order to gainfully employ the years of experience and expertise in various aspects of desalination activity on laboratory scale/pilot scale and to bring down the cost of water by scaling up, Desalination Division has undertaken installation of a hybrid desalination plant as a demonstration project coupled to 170 MW(e) PHWR station at Kalpakkam under IX[th] plan, which would be good enough to meet the dual needs of process water for nuclear power plant and drinking water for the neighbouring people.

Nuclear Desalination Demonstration Project (NDDP) at Kalpakkam aims for demonstrating the safe and economic production of good quality water by nuclear desalination of seawater comprising of 4500 m³/d Multistage Flash (MSF) and 1800 m³/d Reverse Osmosis (RO) plant (Fig.1). MSF plant uses low pressure steam from Madras Atomic Power Station (MAPS), Kalpakkam.

The objectives of the NDDP (Kalpakkam) are as follows:

1. to establish the indigenous capability for the design, manufacture, installation and operation of nuclear desalination plants.
2. to demonstrate the safe and economic production of water.
3. to generate necessary design inputs and optimum process parameters for large size nuclear desalination plant (10 MGD).

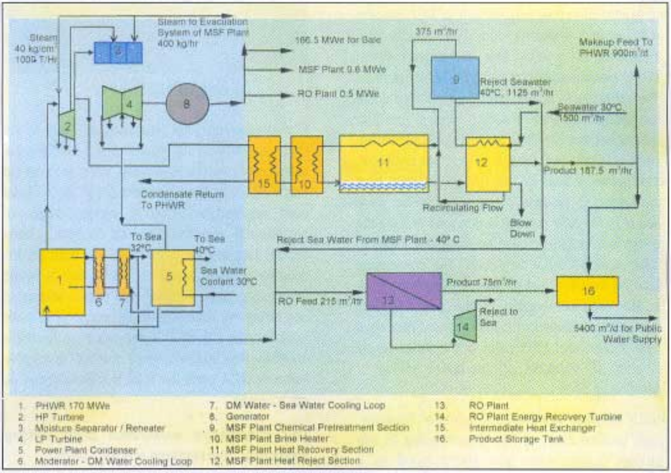

Fig.1 6,300 m³/d hybrid MSF- RO desalination plant coupled to 170 MWe PHWR

The hybrid plant is envisaged to have a number of advantages:

1. A part of high purity desalted water produced from MSF plant will be used for the makeup demineralised water requirement (after necessary polishing) for the power station.
2. Blending of the product water from RO and MSF plants would provide requisite quality drinking water.
3. The RO plant will continue to be operated to provide the water for drinking purposes during the shutdown of the power station.

The 6300 m^3/d combined MSF-RO nuclear desalination project is located in between the existing 170 MW(e) PHWR MAPS and proposed 500 MW(e) FBR at Kalpakkam. The MSF plant uses the required quantity of low pressure (LP) steam for seawater desalination. In order to avoid any chance of ingress of radioactivity (tritium) to MSF process and product water, it has been decided to incorporate an isolation heat exchanger between MAPS steam supply and the brine heater of MSF. The LP steam is tapped from the manholes in the cold reheat lines after HP turbine exhaust from both the nuclear reactors (MAPS I and II). The moisture content is removed through a moisture separator. The steam is sent to intermediate isolation heat exchanger to produce process steam for brine heater of the MSF plant. It is designed to keep the steam temperature in brine heater below 130°C to avoid scaling on the tube side. The condensate from the isolation heat exchanger is returned back to the deaerator section of the power station. Adequate provisions for monitoring and control have been incorporated for isolation of the steam supply in case of shutdown of the power station or desalination plant.

NDDP requires around 2000 m^3/hr of seawater. After detailed study, it has been decided to use process cooling water from MAPS outfall as a source of seawater supply for NDDP. Normally, the cooling water discharge has no debris since the intake water passes through the trash rack and travelling water screens. It is reported to have less biofouling potential.

Fig.2 NDDP site (Kalpakkam)

Considerable progress has been achieved in the implementation of the project. Fig.2 indicates the progress of civil work at the site. Indents for all the major equipment and materials for NDDP have been released and are in various stages of procurement and fabrication at the site. Useful design data are expected from the plant on the coupling of SMR based on PHWR with a hybrid desalination plant. This will also help in scaling up and taking the advantage of the economy of scale to larger size (10 MGD) commercial plants. India will share the O&M experience of NDDP to member states of IAEA when the plant is commissioned as per schedule.

Low temperature evaporation plant utilizing waste heat from research reactor (CIRUS)

As the energy cost contributes about one third of the total water cost, efforts are directed towards the utilization of waste heat which is available free of cost. Desalination Division has an active programme to study the possibility of use of large amount of waste heat of nuclear research reactor and PHWR for seawater desalination using low temperature evaporation technology. The know-how for the desalination plant based on low temperature evaporation (LTE) utilizing low-grade waste heat (as low as 53^{0}C) for producing pure water from seawater was developed. A 30 m^3/d pilot plant was installed and operated for endurance test. This unit is eco-friendly because it does not require exhaustive chemical pretreatment.

Mainstay of Indian nuclear reactors is the PHWR type using natural uranium oxide as fuel and heavy water as moderator and coolant. About 40 MW(th) and 100 MW(th) of waste heat are available in the moderator system of 220 MW(e) and 500 MW(e) PHWR respectively. A significant part of this waste heat can be utilized for seawater desalination. The 30 m^3/d LTE plant earlier established at Desalination Division is being shifted to the CIRUS research reactor for its coupling to the reactor (Fig. 3). The plant will be commissioned in the current year. It will demonstrate the coupling of LTE desalination plant to nuclear research reactor and the feasibility of using low quality nuclear waste heat for seawater desalination. The plant eliminates the elaborate chemical pretreatment of feed water for producing demineralised water. The data from this plant will be useful for design of larger size LTE seawater desalination plant for the production of demineralised water and process water.

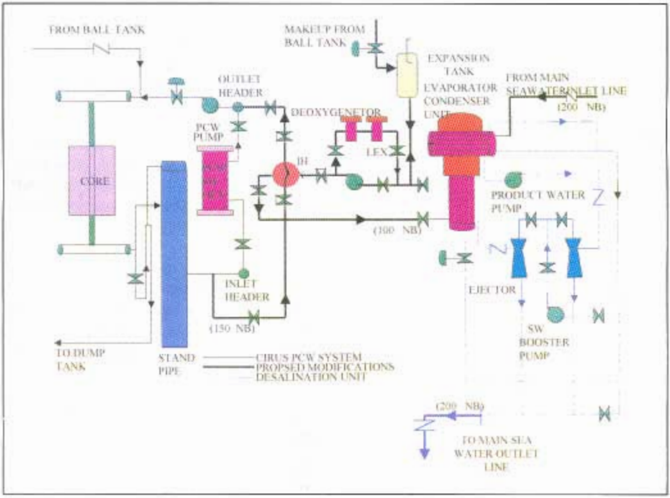

Fig.3 Schematic diagram of the LTE desalination plant coupled to nuclear reactor (CIRUS)

Such plants would be ideal for industries where waste heat is available in the form of fuel gas and process heat. It is an attractive alternative for producing pure water from high salinity or sea water for the rural areas where waste heat from DG sets/ solar energy is available. Consultancy services were provided to the Union Territory of Lakshadweep in utilizing the waste heat of the DG sets for LTE desalination. A 10 m^3/d LTE desalination plant utilizing the waste heat of 400 KVA generator has been operating in Kavaratti for producing pure water from seawater.

The total water requirement for the LTE desalination plant is quite high. Work has been initiated to bring down the total water requirement by 20-30 times by coupling a cooling tower and recycling the condenser water. It will be a totally indigenous, reliable and rugged desalination system. Energy requirement can be further brought down by employing more number of effects. The design of such plants of larger capacity for Advanced Heavy Water Reactor (AHWR) program has also been taken up. Studies are undertaken towards utilizing low quality waste heat from the steam and feed water system of AHWR for producing demineralised (DM) water from high salinity water or sea water.

Innovative Developments Undertaken

Improved heat transfer for MED

Basic studies carried out earlier on a horizontal tube thin film (HTTF) boiling indicate that the bubble nucleation in the thin film on the tube takes place with rapid bubble growth. The application of forced convection due to liquid spray on the tube increases the convective contribution and results in early removal of bubble adhering to the surface which increases bubble frequency. The overall heat transfer coefficient in the range of 3-4 kW/m^2K was obtained which is about three times the heat transfer coefficient as compared to submerged tube evaporator. High heat transfer coefficient implies low heat transfer area requirement and in turn low capital cost. The data collected on the fluid flow and heat transfer aspect of the boiling in a thin film were used in the design and installation of 1 m^3/d HTTF desalination unit for MED (Fig. 4). Low temperature vapour compression desalination plants of 50-200 m^3/d capacities are suitable for providing drinking water in the rural/ water scarcity areas and process water/ boiler feed water for industries. MED with mechanical vapour compression is ideal for areas where only electrical energy is available and sufficient cooling water is not available. MED with thermocompression are suitable for the regions where high pressure (5-10 bar) steam is available.

Fig.4 HTTF desalination unit for MED

It produces low conductivity water directly from the high salinity water. It is planned to carryout high temperature MED studies using nanofiltration (NF) in the upstream for the makeup feed pretreatment. Laboratory data on NF indicate substantial reduction of the scale causing constituents in seawater when it is passed through it. The use of NF permeate as makeup feed to MED will provide high Gain Output Ratio (GOR) by operating it at higher top brine temperature. NF helps in removing the total hardness thus reducing the energy and chemical consumption.

Improvements in reverse osmosis for desalination

The RO desalting industry is looking for continued reduction of the cost of desalted water. This calls for the development of better quality membranes offering higher output while maintaining the optimum salt rejection, reduced chemical pretreatment, longer membrane life and low energy requirement.

Fig.5 SWRO pilot plant at Trombay

R&D work on indigenous development of advanced polyamide based thin film composite (TFC) membranes has been undertaken at the Division to meet these objectives. After successful development of brackish water RO desalination plants to demonstrate the utility of RO desalination systems in meeting the drinking water needs of brackishness affected villages, a 40 m^3/d seawater RO plant has been setup in Trombay for producing drinking quality water (Fig. 5). The plant is being upgraded to 100 m^3/d capacity. The conventional pretreatment system has been setup, which includes chlorination, clarification, media filtration, chemical dosing and cartridge filtration. It is planned to introduce membrane based pretreatment system using ultrafiltration (UF) and nanofiltration (NF). The adoption of UF and NF is envisaged to reduce the elaborate feed treatment for removal of scaling constituents, suspended impurities, organics and microbial load. UF installed upstream of RO is very effective as a pretreatment setup. Preliminary investigations have been carried out by using NF as a means to improve the performance of desalination plant. NF reduces the hardness ions of calcium, magnesium and sulfate to a great extent. It also partially reduces the TDS of seawater. This results in reduced seawater treatment and higher recovery.

A brackish water RO plant is setup in Rajasthan in cooperation with Defence Laboratory, Jodhpur, for providing drinking water to the villagers from high salinity brackish water sources. Another RO plant is to be set up at village Chadi (Barmer) for removal of excess fluoride and nitrate apart from brackishness.

Effluent treatment and zero discharge

Due to an increasing demand for good quality water, attempts have been directed to treat the waste water for reuse and recycle. The approach is further reinforced by the need to preserve the environment and to follow a zero discharge concept wherever possible. R&D work in the field of thermal and membrane processes has been pursued for the treatment of waste water and removing pollutants from the effluent stream for safe discharge into environment and recovery of significant fraction of the water for reuse. Selection of a process for treatment of a particular waste water is based on product requirements, influent water characteristics and cost. Industrial waste water often is the combined product of a number of different manufacturing processes in the complex. The membrane processes that are useful for waste water treatment include: microfiltration, ultrafiltration, nanofiltration and reverse osmosis. The suspended solids in waste water are successfully removed by microfiltration. Ultrafiltration is useful in separating macromolecules and the submicron particles including oil emulsion and very large molecules such as polymeric compound having a polymeric weight of 1000 and above. Nanofiltration is capable of separating molecules in the range of 300-1000 molecular weight. It also helps in selective separation of low molecular weight organics from salt solution. Reverse osmosis has very small pore size (5-10 A^o) suitable for removing ions and molecules. Laboratory scale studies are continuing on development of such membranes and their performance evaluation. As no two waste waters are exactly alike, it is necessary to carryout laboratory evaluations to determine the flux rate under different temperatures and pressures for individual waste water samples. LTE and VC desalination is ideal for treating high salinity effluent and producing pure water for reuse.

Barge mounted desalination unit

Barge mounted desalination plant offers a suitable choice for remote locations and small islands or coastal communities where the necessary manpower and infrastructure to support desalination plants are not available. It can be installed anywhere anytime depending on the need in coastal regions. It can supply potable water to remote coastal regions or islands where both good quality water and the energy sources are severely lacking. It does not require intake or outfall infrastructure. It is planned to setup a barge mounted 50 m^3/d seawater RO plant. The preliminary details have been worked out. The design considerations of a barge mounted plant are different from those of land based plant. The limitations due to marine environment including conditions of sea and wind, space availability, weight limitations and technical considerations including pump cavitation and vibration are considered in the design stage.

Participation in the IAEA activities on nuclear desalination

Guidebook on 'Introduction of Nuclear Desalination': Contributions were made in the preparation of a guidebook on 'Introduction to Nuclear Desalination' and a number of TECDOCs related to nonelectrical applications.

Optimization of the coupling of nuclear reactors and desalination systems : Desalination Division has undertaken a Coordinated Research Project (CRP) entitled 'Performance Improvement of Hybrid Desalination Systems for Coupling to Nuclear Reactors' (IAEA Research Contract No. 10245/RO) for optimization of the coupling of nuclear reactors and desalination systems. The objective of the applied research project is to study the behaviour of MSF, RO and LTE plants under different operating conditions utilising data for improving the performance of hybrid MSF-RO plant coupled to PHWR, and LTE plant coupled to nuclear research reactor.

Economic research on, and assessment of, selected nuclear desalination projects and case studies : It is proposed to take up another CRP entitled 'Economic Assessment of Hybrid Nuclear Desalination Project' for the economic research and assessment. The study would involve evaluation of the economic aspects of hybrid nuclear desalination project. The competitiveness of the hybrid nuclear desalination under specific conditions would be studied. Emphasis will be laid on aspects of cost reduction strategies through technological innovations in both thermal and membrane processes. Economic assessment will be useful in establishing the hybrid nuclear desalination plants for the ultimate benefit of the society.

Conclusions

The development work has generated capability in the country to design, fabricate, commission and operate small and large size desalination plants. Efforts are now directed towards reducing the cost of desalted water through technological innovations. In the case of thermal processes, this calls for capital cost reduction through heat transfer enhancement and use of cheaper materials, low grade or waste heat utilization and least chemical pretreatment. Today, production of boiler quality water and high quality process water from sea water desalination is cheaper than that produced from conventional DM plant using raw water where the raw water contains 500 ppm or more salinity. In the case of membrane processes, attempts are continued towards the development of better membranes, least pretreatment, longer membrane life and reduced energy consumption. Effluent treatment and water reuse through desalination route, as a step towards zero discharge, appears promising. The development of barge mounted desalination units will go a long way as a means of pure water supply to remote coastal areas anywhere and at anytime. The technological innovations in desalination would lead to its large scale application and provide opportunities for the socioeconomic development of water scarcity areas and large coastal arid zones of the country.

LASER- SCAN DIA- GAUGE FOR FUEL PELLET DIAMETER MEASUREMENT

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Dimensions like diameter and length are very accurately required for a Fast Breeder Test Reactor (FBTR) pellet in order to facilitate its smooth loading inside the austenitic stainless steel clad tube. In the past, Linear Voltage Differential Transformer (LVDT) probes have been used to measure diameter and length in Radiometallurgy Division, BARC. Radioactive environment in the box led to serious maintenance problems for these measuring units.

A non-contact remote technique under these circumstances is very useful. An optical technique for diameter measurement based on Laser beam scanning had been earlier developed in Laser & Plasma Technology Division (LPTD), BARC. The principle of measurement is that a fine beam of visible light from Diode Laser scans a vertical plane after reflection from a rotating mirror mounted on the shaft of a DC motor. The scanning beam is collimated by a plano convex lens. An object kept perpendicular to the plane of scanning obstructs the beam for the time proportional to its dimension. The collimated beam after passing through measuring plane is focused by a lens on a photodiode. The output of photodiode carries the shadow pulse of the object whose width is measured electronically through high-speed counter to calculate the dimension of the object.

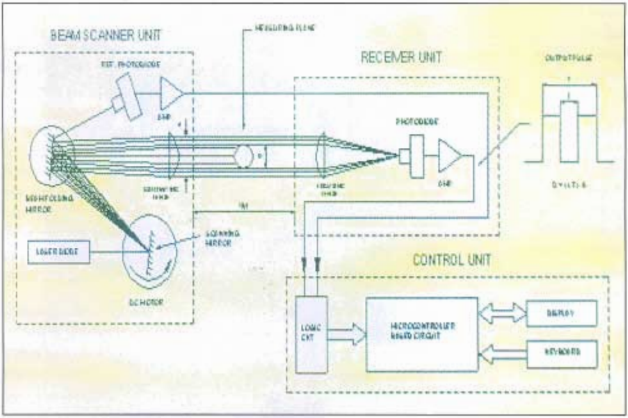


Fig. 1 Schematic of laser-scan dia-gauge

The diameter of the object is calculated according to the formula:

d=(t/T)xD+offset;

where

d=diameter of the object,
t=shadow pulse width,
T=Aperture pulse width,
D=Diameter of Aperture
Offset –due to finite beam size

An instrument has been developed using the above principle, viz LASER-SCAN DIA-GAUGE, and its technology transferred to two outside industries, viz 1)M/s Suresh Indu Lasers Pvt. Ltd, Pune, 2) M/s Jasch Industries Ltd, New Delhi.

Using the same principle of laser beam scanning, a modified instrument has been developed at LPTD for measurement of fuel pellet diameter from outside the glass walled Glove Box of about one metre width. It consist of three parts:

i) Beam Scanner unit.
ii) Receiver unit.
iii) Control unit.

In Beam Scanner unit, a laser beam (from Diode Laser, 670 nm) scans a vertical plane after reflection from a rotating mirror mounted on the shaft of a DC motor (Fig 1). To save the horizontal space, the beam is folded by a mirror, after reflection from the scanner, towards collimating lens (a plano convex lens to collimate scanning beam).

As the instrument is to be kept outside the glove box, the minimum separation between beam scanner unit and receiver unit is 1 metre. The object (fuel pellet) will be near the center of the glove box around 50 cm away from the beam scanner unit. The collimating lens is of 25 mm diameter and 500 mm focal length.

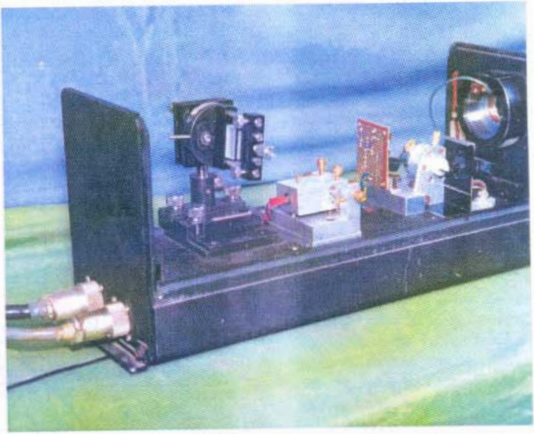


Fig. 2 Beam scanner unit

← 1 Metre →

Fig. 3 Diameter measurement by laser meter

In the laboratory, the unit has been tested with the separation between beam scanner unit and receiver unit being about 1 metre. Two glass plates similar to the glass walls of Glove Box have been kept in between the scanner and receiver unit with one plate near each unit.

The Receiver unit consists of focusing lens and a photodiode-amplifier card. The lens focuses the incoming scanning beam onto a photodiode (Fig 1). The output of photodiode carries the shadow pulse of the object (fuel pellet). The amplifier output is fed to the control unit.

The Control unit consists of schmitt trigger, logic circuit, counters, microcontroller (87c51), LCD and keyboard interface. The output of Receiver unit is passed through schmitt trigger and logic circuit to generate the Gating pulses for high speed (100 MHz) counters. At the end of each scan, the microcontroller reads the counter values corresponding to total pulse width (of aperture) and shadow pulse (of object) and calculates the diameter value. The value thus calculated is displayed on LCD. A keyboard is provided on the Control unit through which two functions are available to the user:

i) Changing the number of Averages. By increasing the averaging figure, the measuring time is increased but it improves the accuracy/ repeatability.

ii) Setting the lower and upper limit to sort out samples within acceptable range.

A RS–232 serial interface is also provided to transfer the data (diameter value) to PC for data analysis.

The specifications of the instrument are as follows:

Measuring Range	: 5 mm to 20 mm
Accuracy	: 10 micron
Repeatability	: ±2 micro
Scan Rate	: 40 per second
Measuring Time	: 1 second
Laser	: Diode Laser at 670 nm.

The instrument has been tested for actual working conditions. It is now proposed to use two such instruments for diameter as well as length measurement of fuel pellet in a continuous on-line quality testing process.

Based on the same principle of scanning, a multi-point diameter measuring system is under development using line scanning for simultaneous diameter measurement on 32 points along the length of a 100 mm long clad tube at 3 mm interval. The system has been designed using Laser line generator, line collimator, line canner, cylindrical collimating lens, cylindrical focusing lense, multi-photodiode card with amplifier, logic circuit cards, high speed counter PC add-on cards and Industrial PC. It will display the multi-point diameter values on-line on PC monitor and store these for further analysis purpose.

DIRECTOR, BARC, VISITS POTON PROJECT SITE AT LASALGAON

On June 25, 2001, Mr B. Bhattacharjee, Director, BARC, visited the POTON Project site along with Dr. D.R.Bongirwar, Project Manager, Food Irradiation Project, to get the first hand information about the progress of project work after assuming the charge of Director, BARC.

Mr B. Bhattacharjee, Director, BARC, at the POTON Project site at Lasalgaon

Mr P.B.Kulkarni, Associate Director, Engineering Services Group and Head, Technical Services Division, Mr S. Ramanujam, Head, Architecture & Civil Engineering Division, Dr M.C.Abani, Head, Reactor Safety Systems Division, Mr B.N. Maheshwari, Head, Landscape & Cosmetic Maintenance Section, Mr D.S.Lavale of Board of Radiation and Isotope Technology (BRIT), Mr R.K.Modi, Mr M.G.Radke and Mr R.P.Hans of Division of Remote Handling & Robotics, BARC, Mr Vijayan and Mr Mau Khan from Technical Services Division, Dr A.R.Nayak of Reactor Safety Systems Division, BARC and contractors of Mather & Platt, Symec and Prakash Constrowell Companies, staff of Food Irradiation Project, Press personnel and photographer were present at site to welcome the Director, BARC, and brief him about the progress of works at site. Mr Bhattacharjee discussed the works getting delayed in respect of Product Handling System of the Irradiator with DRHR personnel and the contractor, Mr Kulkarni of M/s Mather & Platt Co. of Pune, who are installing this system. Mr Bhattacharjee informed the contractor that as the project was of national importance, it needed to be completed in a time-bound manner. Mr Bhattarcharjee was assured by the contractor that the job would be completed in 21 days' time. Mr Bhattacharjee told the contractor that if the job was not completed satisfactorily within the stipulated time, BARC would be free to terminate his contract and get the job executed by an alternate contractor. Later, the Director planted a tree sapling at the site. Mr Bhattacharjee then went to the National Horticultural Board's godowns and storage structures where selection, grading and packing of onions are carried out and onions are stored for long duration, viz. from 2 to 4 months. Dr. Lalan Singh, Jt. Director, NHB, and Mr Mishra , Asst. Director, NHB, explained to Mr Bhattacharjee the role of NHB and its objective, and told him that Radiation Processing Plant in this area would be very useful to farmers, traders, co-operatives and exporters. Mr Kulkarni, Branch Manager, NAFED, and his assistants explained to Mr Bhattacharjee the role of NAFED, its objectives and areas of functioning when he visited its godowns and the 2 & 3 tier onion storage structures for storage for 3 to 4 months. Director, BARC, also visited the APMC Market yard and enquired about trading procedures. A local press personnel from *Dainik Sakal* interviewed Mr Bhattacharjee about the benefits of POTON plant. He also enquired whether small and marginal farmers' produce could be irradiated in this plant. Mr Bhattacharjee along with Dr. Bongirwar answered all the questions of Press personnel and told that any farmer can get his commodity treated in this plant once it became operational. However, methodologies for undertaking irradiation operation will be streamlined soon in the near future. In the end, Mr Bhattacharjee remarked that all efforts must be made to complete the project work in the quickest possible time and commission the plant for public use as early as possible.

SYMPOSIUM ON 'TRENDS IN POST-GENOMIC BIOLOGY'

A half-day symposium titled "Trends in Post Genomic Biology" was organised by Molecular Biology and Agriculture Division of BARC on the occasion of the superannuation of Dr. D.S. Joshi, Head, Flow Cytometry and Mammalian Genetics Section of MB&AD. The meeting was held at the B Block auditorium of Modular Laboratories in the afternoon of April 2, 2001. Dr Joshi served science for 36 years and was one of the early ones in the country to initiate application of Flow Cytometry to various areas in biology. He later moved to the field of Human Molecular Genetics.

Inauguration of the symposium on "Trends in Post-Genomic Biology". On the dais are (from left to right), Dr S.K. Mahajan, Head, MB&AD, Dr D.S. Joshi, Dr (Ms) S.D. Joshi, Medical Social Welfare Officer and Dr (Ms) A.M. Samuel, Director, Bio-Medical Group, BARC.

The symposium was attended by more than 100 researchers from different institutes of Mumbai including BARC. National and International collaborators of Dr Joshi and other leading experts gave deliberations on molecular biology of important aspects of human life as briefed below. Dr. S.G.A. Rao, Research Director, Harkisandas Hospital, talked on "Haematopoetic Stem Cells and their Therapeutic Potential". Dr Suresh Advani, Head, Medical Oncology, Tata Memorial Centre, gave an overview of "Pharmacogenomics and New Molecular Targets". Dr Amal K. Mukhopadhyaya of Institute for Hormone and Fertility Research, Hamburg, Germany, lectured on "Biology of Aging - the Dilemma of the Male ". Dr. Stephen Gilbert Hillier, Director, Graduate School of Life Sciences, University of Edinburgh, U.K., elaborated on "The New Biology of Ovulation". Dr Pascal Pujol of INSERM, Montpellier, France, gave an insight on "Estrogen and Ovarian Tumor Progression". Dr Swati Patankar, Scientist, GenMed, Mumbai, explained the techniques and results of "The Genomic Analysis of the Malarial Parasite *P. falciparum* using Serial Analysis of Gene Expression (SAGE)". The symposium gave an impetus for the future research in functional genomics, proteomics and evolving technologies.

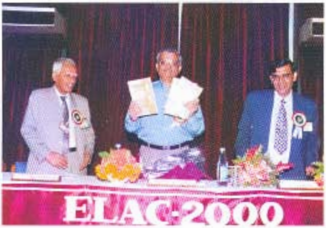
WORKSHOP-CUM-SEMINAR ON 'ELECTROANALYTICAL CHEMISTRY AND ALLIED TOPICS' (ELAC-2000)

A Workshop-cum-Seminar on 'Electroanalytical Chemistry and Allied Topics (ELAC-2000)' was held during November 27- December 1, 2000 at BARC Training School Hostel, Anushaktinagar, Mumbai. It was sponsored by Society for Advancement of Electrochemical Science and Technology (SAEST), Bombay Chapter, Board of Research in Nuclear Sciences (BRNS), Department of Atomic Energy (DAE), Mumbai and Council of Scientific and Industrial Research (CSIR), New Delhi.

The topics covered were conventional Electrochemical Techniques like Potentiometry, Amperometry, Coulometry, Conductometry, etc. for the elemental determinations, applications of advanced Voltammetric Techniques in Environmental, Biological and Processing industries, High Purity Materials, Corrosion, Coupling Ultrasound to Electrochemistry, Sensors, etc.

Dr. Anil Kakodkar, Chairman, Atomic Energy Commission, inaugurated the seminar. Dr S.K.

Aggarwal, Chairman, National Organizing Committee and Head, Mass Spectrometry Section, Fuel Chemistry Division, BARC, welcomed the delegates and highlighted the theme of the workshop-cum-seminar. Prof. A.S. Khanna, Chairman, SAEST, Bombay Chapter, briefly summarised the growth and the activities of SAEST.



Dr Anil Kakodkar, Chairman, Atomic Energy Commission, releasing the Abstracts Volume during the inauguration of ELAC-2000. On the dais (left to right) are Mr D.S.C. Purushotham, Director, Nuclear Fuels Group, BARC, and Prof. A.S. Khanna, Chairman, SAEST, Bombay Chapter

Mr D.S.C. Purushotham, Chairman, National Advisory Committee and Director, Nuclear Fuels Group, BARC, highlighted the role of Electroanalytical Chemistry in Nuclear Science and Technology in his presidential address.

About 100 delegates from DAE, National and International Laboratories, Industries and different Universities participated in the seminar. A special session was devoted to Electrochemistry in Nuclear Technology. Also, one session was devoted to Research Scholars for oral presentations of their research work. A total of 30 invited talks, including 8 by foreign delegates, were delivered. 28 Research Scholars presented their papers and there were 20 poster presentations of the contributed research work. These papers have been included in the preprint volume and distributed to delegates at the time of registration.

Delegates actively participated in the discussions during the sessions. The high quality of the papers was greatly appreciated and it was suggested that this type of seminar should be organized regularly.

GAMMA SCANNING OF A VACUUM COLUMN FOR MANGALORE REFINERY & PETRO-CHEMICALS LIMITED

Isotope Applications Division, BARC, carried out gamma scanning of 9.5 metre diameter Vacuum Column for Mangalore Refinery & Petrochemicals Limited, Mangalore. This is the first time that gamma scanning technology has been used for troubleshooting for such a large diameter and thick walled industrial process column. The malfunctioning of the column was resulting in production of low quality product and the company was losing about Rs 20 lakhs per day. A specially fabricated composite material source container-cum-collimator system consisting of lead, depleted uranium and heavy alloy for housing 700 mCi of Cobalt -60 source was used for this work. As per our recommendations, the authorities planned the shutdown and opened up the column and found damage to the column internals as indicated in our report. Successful pin-pointing of the problem by gamma scanning enabled the authorities to reduce the shut down period of about 15 days, thus avoiding huge production loss. Deputy General Manager of Mangalore Refinery and Petrochemicals Limited thanked BARC for the help and analysis of their problem and identifying the troublesome areas.

TRAINING UNDER IAEA FELLOWSHIP, RCA AND BILATERAL AGREEMENTS

In the year 2000-2001, BARC provided training to 26 scientists from 8 countries under the IAEA Fellowship Programme, Regional Co-operation Agreements and Bilateral Schemes. The table below gives the list of trainee scientists. At the end of their training, certificates were given to them by Mr A.K. Anand, Director, Technical Co-ordination and International Relations Group, BARC.

Certificate of training being received by an IAEA Fellow of Sri Lanka from Mr A.K. Anand, Director, Technical Coordination and International Relations Group, BARC.

Country	Name of the Fellow	Field of Training	Division	Duration in weeks
Bangladesh	Md. Jahidul Kabir	Non-Destructive Testing	CWS	6
Egypt	Ms Nadia Abd-El-Mouty	Hybridoma Technology	RMC	12
Indonesia	Mr Fadil Nazir	Nuclear Medicine	RMC	26
Myanmar	Mr Aye Mint	Material Processing	REDS	13
	Mr N. Nyan Win Aung	Radioisotope Production & Neutron Activation Analysis	IAD	13
	Mr Maung Maung Soe	Reactor Safety Analysis	RSD	13
	Mr Wai Zaw	Radiation Processing	AERB&BRIT	26
	Ms Khin Khin Lay	Radiation Processing & Neutron Activation Analysis	BRIT&IAD	13
Sri Lanka	Dr (Ms) K.D.C. Liyanage	Radioimmunoassay	RMC	2
	Mr A.A. Samaraweera	Radiotracers & Sealed Sources	IAD	13
	Ms E.T. Tilanie Wimla	Radioimmunoassay	RMC	13
	Ms Saroja Sriwardena	Radiopharmaceuticals	RMC	4
	Ms Ruwanpura Mendis	Radiopharmaceuticals	RMC	13
Uganda	Mr Mathias Obaa	Radiation Safety	RPAD	8
Vietnam	Mr Dao Duy Dung	Radiation Technology in Industry	IAD	14
	Mr Dinh Cong Bot	Anal;ytical Techniques	ACD & NFC	14
	Mr Ho Tien Dung	Reactor Physics	ThPD	13
	Mr Nguyen Duc Hung	Ore Dressing of Rare Earth	ODS & IRE	14
	Mr Nguyen Duc Thanh	Production of Rare Earth Chems.	RED & IRE	14
	Mr Nguyen Duy Lam	Uranium Metal Oxide Processing	UED & NFC	14
	Mr Nguyen Van Sinh	Material Processing	UED & NFC	14
	Mr Nguyen Viet Thuc	Analytical Techniques	ACD & NFC	14
	Ms Vo Thi Cam Hoa	Radiopharmaceuticals	RMC & BRIT	13
	Ms Vo Thi Tuong Hanh	Radiation Monitoring in Food	IAD	14
Yemen	Dr (Ms) Asma Alsalami	Radiation Accidents	RPAD	4
	Dr Mohamad Almansoor	Radiation Accidents	RPAD	4

BARC SCIENTISTS HONOURED

• Ms Jayshree V. Kamat of Fuel Chemistry Division, BARC, was awarded the 1st prize for the best oral presentation during the Workshop-cum-Seminar on 'Electroanalytical Chemistry and Allied Topics (ELAC-2000)' held at BARC Training School Hostel, Anushaktinagar, Mumbai, during November 27- December 1, 2000. The award was for the paper, "Studies on Voltammetric Determination of Gallium in Dilute Hydrochloric Acid at Glassy Carbon Electrode", by J.V. Kamat, N. Gopinath, H.S. Sharma and S.K. Aggarwal.

• Mr N. Gopinath of Fuel Chemistry Division, BARC, was awarded the 1st prize for the best oral presentation during the Workshop-cum-Seminar on 'Electroanalytical Chemistry and Allied Topics (ELAC-2000)' held at BARC Training School Hostel, Anushaktinagar, Mumbai, during November 27 - December 1, 2000. The award was for the paper, "Determination of Uranium and Plutonium in Nuclear Fuel Materials by Electroanalytical Methods", by N. Gopinath, J.V. Kamat, N.B. Khedekar, K.V. Lohithakshan, P.D. Mithapara, P.R. Nair, B.N. Patil, K.A. Mathew, M. Renuka, Keshav Chander, H.S. Sharma, Mary Xavier and S.K. Aggarwal.

• Dr Sharad Eknath Pawar, Head, Pulses Improvement Section, Nuclear Agriculture & Biotechnology Division, BARC, has been honoured with the ISPRD Recognition Award 2001 by the Indian Society of Pulses Research and Development, Indian Institute of Pulses Research (ICAR), Kanpur, for his outstanding contributions in the field of Pulses Improvement. His work has resulted in the release of 10 varieties of pulses, 4 each of mungbean and urdbean and 2 of pigeonpea. He is a fellow of several national academies. He is also a consultant to National Dairy Development Board, Anand, for developing quality Indian mustard. The present award carries a citation and a memento.

• Ms J. Latha of Nuclear Agriculture & Biotechnology Division, BARC, was presented "Dr G.R. Damodaran Memorial Award" for the Best Paper Presentation at the National Seminar on 'Microbial Technology-mt2001', held at Dr G.R. Damodaran College of Science, Coimbatore, during 1st & 2nd June, 2001. The award carries a citation and cash prize of Rs. 2000/-. The paper titled, "Molecular Evidence that the Indian Population of *Collectotrichum graminicola* (Sorghum Anthracnose) is Hypervariable", was authored by J. Latha, A. Chakhrabarti, P.K. Mukherjee and R.P. Thakur.

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