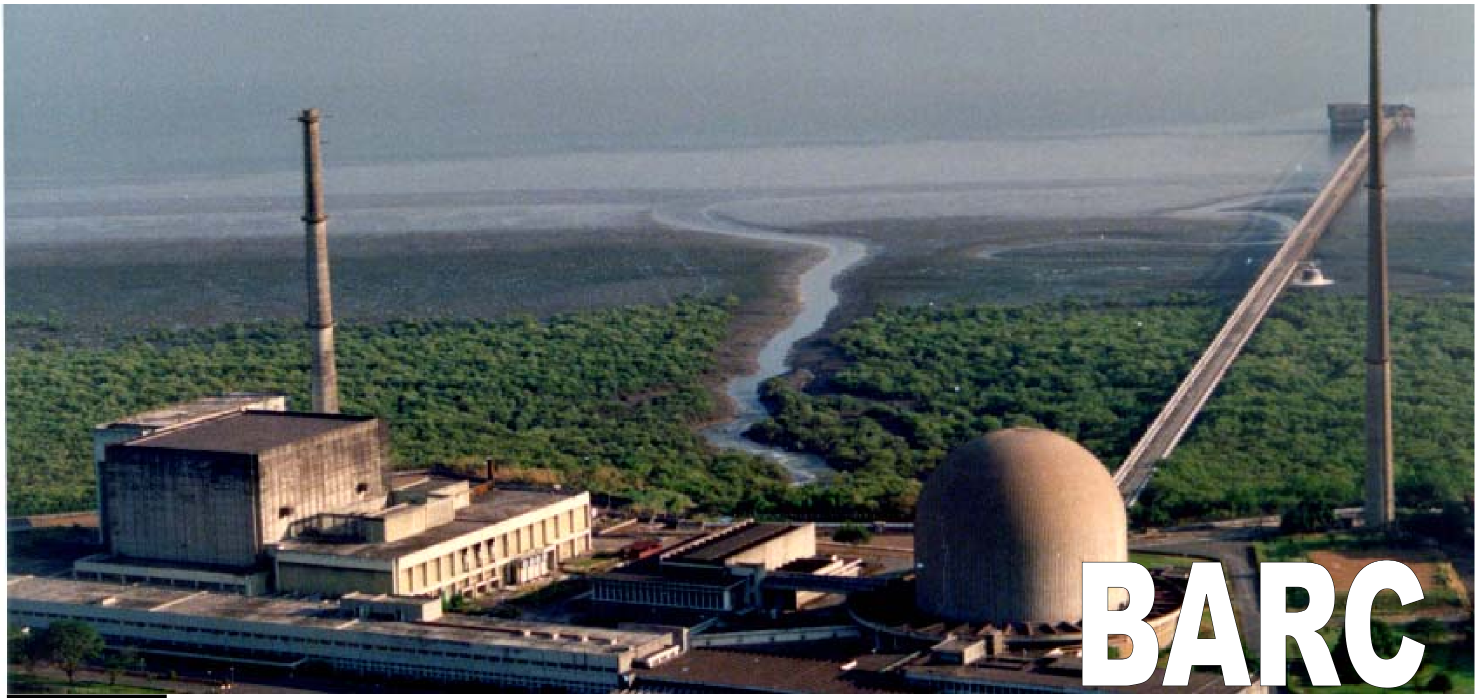

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Department of Atomic Energy
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August 2003 - August 2004

# CIRUS RESEARCH REACTOR : ITS REFURBISHMENT AND FUTURE UTILISATION

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## Introduction

CIRUS was built in the late fifties with Canadian assistance and attained its first criticality on July 10, 1960. It is a thermal neutron reactor fuelled with metallic natural uranium and has a vertical reactor vessel made of cylindrical aluminium tank. Heavy water is used as moderator and graphite as reflector in the form of two concentric rings around the reactor vessel. The reactor has a rated thermal power of 40 MW. Heat produced in the fuel is removed by de-mineralised light water circulated in a closed loop. The light water primary coolant, in turn, is cooled by sea water in once through mode.

Utilisation of CIRUS, both in terms of quantity and quality, has been of a very high standard. The reactor performed well for more than three decades with availability factor of over 70 %.

## Refurbishment

During early nineties, signs of ageing started surfacing up and were reflected in the availability factor of the reactor which started declining due to the increase in the

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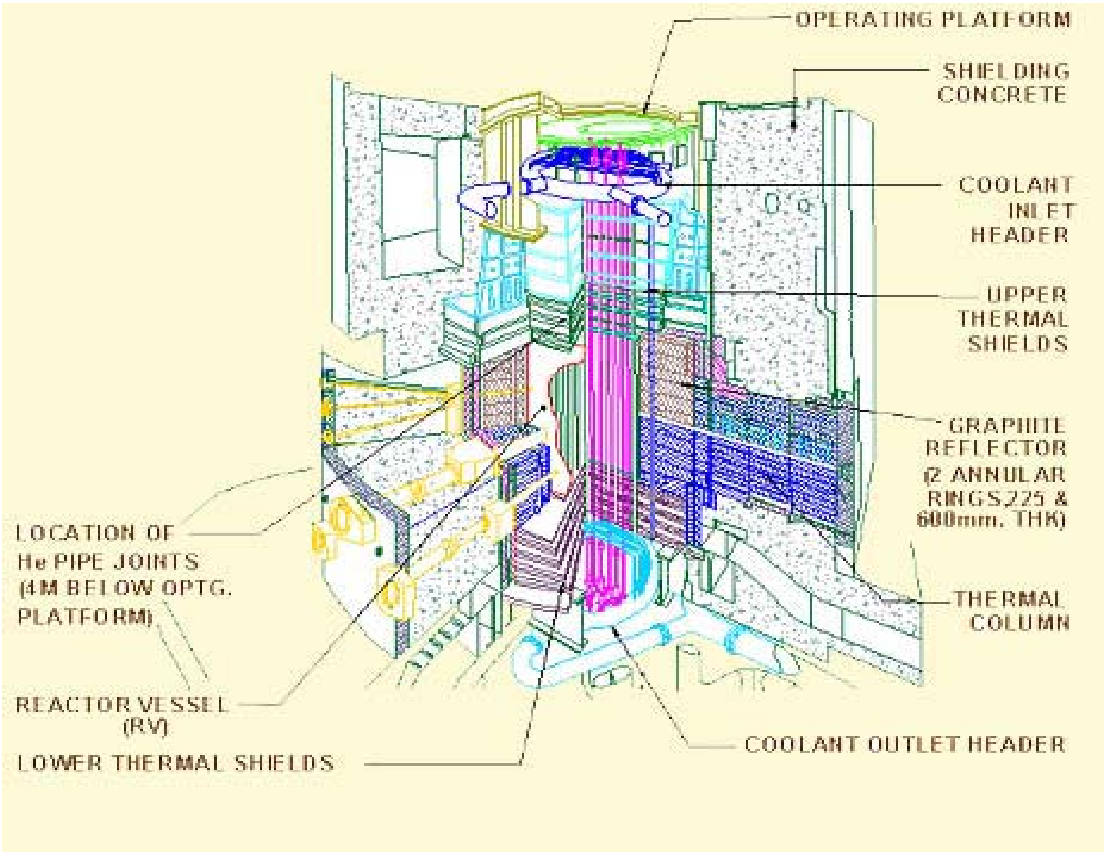



*CIRUS reactor structure cross section*

frequency of equipment outages and the considerable effort and time requirement for bringing the equipment back into service after repairs.

Therefore, at that point of time, detailed ageing study on reactor systems, structures and components was undertaken to examine in detail the technical viability of extending life of the reactor by appropriate corrective measures to compensate for the ageing with the aim of allowing another 10 to 15 years of intensive continued operation of CIRUS.

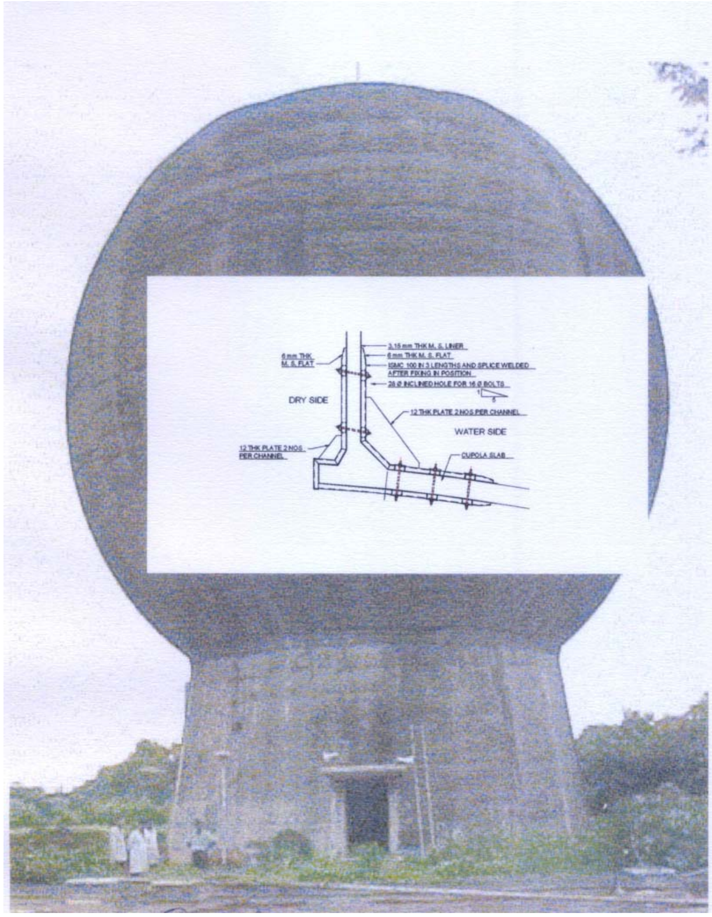
After completion of detailed evaluation of the results of the study, refurbishing requirements of critical plant components were identified and a comprehensive plan was drawn up. Regulatory consent was obtained for implementation of the plan. The refurbishment outage was seen as an opportunity for safety upgrade and accordingly the action plan encompassed several safety upgrades to cope up with the current standards. The procurement of necessary equipment was initiated well in time. The reactor was shut down during October, 1997 to carry out major repairs and various activities as per the refurbishment plan.

## Achievements

Some of the main achievements of refurbishment are :

- For rectification of seepage from the central shaft of primary coolant emergency reservoir (Ball tank), the tank was emptied soon after core unloading. The concrete wall in leaky region was repaired by chipping old plaster and cementing with polymer modified mortar followed by pressure grouting at selected locations. Strengthening of central shaft and cupola joints, was achieved by additional reinforcement with mild steel plates and epoxy grouting to make it a monolithic structure to meet safe shut down earth quake qualification criteria.

- Several mechanized inspections and metallurgical studies undertaken towards re-qualification of reactor vessel and tubes for many more years of operation.
- Replacement / reconditioning (as required) of the underground (4 metres below ground) carbon steel primary coolant pipe lines with provision for monitoring the leakage from the underground piping.




*CIRUS Ball tank : Central shaft strengthening*

- Installation of split sealing clamps with remote handling techniques towards rectification of helium leak from the tongue and groove joints of cover gas system located in inaccessible area below the biological shields of the reactor.
- Installation of a new failed fuel detection system based on gamma radiation monitoring. The old system was based on gaseous fission product stripping method and it used to result in substantial radiation exposure of O&M personnel.
- Rectification of leak from the weld joint of inlet line to the upper aluminum thermal shield by installation of hollow plug using remote handling techniques.
- Physical separation of Ball tank make up pumps, a safety related equipment, to guard against common cause failures.
- Installation of more efficient iodine removal system having activated charcoal cum HEPA filters in place of obsolete system of alkali scrubber followed by silver coated copper wire mesh iodine filters.
- Detailed studies and theoretical analysis towards assessing the thermal safety of the Graphite reflectors was carried out and it was concluded that there was no need to undertake planned annealing of graphite reflector since release of stored energy, if any, would be within the cooling capability of pile block ventilation system under any design basis event.

## Start Up

After completion of refurbishment activities and commissioning of various systems, CIRUS reactor was made critical on October 30, 2002 and rededicated to the nation by Honourable Prime Minister of India.

At this stage, some seepage was observed from a few locations on the pour joints of spherical concrete surface of Ball tank. Also, the observed critical height of moderator was found to be higher than the estimated one indicating core reactivity anomaly of the order of 12 milli k. The reactor was kept shut down for repairs to rectify the seepage from Ball tank.

The Ball tank was emptied again and necessary repairs were carried out by lining entire internal surface exposed to water with eight layers of epoxy coating impregnated with two layers of fiber-glass cloth. The Ball tank was commissioned and ensured to be free of leak or seepage.

The core reactivity anomaly, after detailed investigations, was attributed to the wetting of graphite reflector caused by water spillage from primary coolant system in upper service space due to failure of a trunnion valve during fuelling operations. Site constraints and other safety considerations did not permit quick removal of moisture from the graphite region by accelerating drying. Operation of the reactor at high power was the appropriate option for raising the temperature of graphite for gradual removal of moisture. Operation of reactor at power, raised in steps, was taken up with due safety clearances. Reactor was re-started on October 3, 2003.

## Operation at Power

At the first step of reactor operation on power at 4 MW setting, it was observed that the thermal power of the reactor was about 12 MW. The mismatch between neutronic and thermal power was attributed to attenuation of neutron flux by moisture present in graphite reflector and thermal column where reactor regulating system (RRS) ion chambers are located.

The mismatch was offset by appropriate combination of repositioning of the reactor regulating system ion chambers and adjustment of gain of amplifiers after careful review and safety clearances at every stage of reactor power increase.

The reactivity anomaly gradually decreased with progressive operation of reactor at power.


*30 Te/day Desalination Unit at CIRUS*

After significant improvement in neutron flux at the location of RRS ion chambers and reduction of reactivity anomaly to about 2 mk; the reactor power was raised to 30 MW during February, 2004 after normalising the position of the RRS ion chambers.

After reduction of reactivity anomaly to insignificant level, the reactor power will be raised to 40 MW in steps shortly.

### Perspectives & Future Utilisation

A Desalination Unit of 30 tonne/day capacity, based on Low Temperature Vacuum Evaporation (LTVE) process, has been integrated with primary coolant system of the reactor towards demonstration program for utilisation of waste heat from nuclear reactor.

The utilisation of irradiation facilities of the reactor has been commenced with the irradiation of samples in "self-serve" units and in-core tray rods. The Pneumatic Carrier Facility was commissioned and being utilised well.

Use of various neutron beam ports and positions for irradiation of Cobalt /Thorium in graphite reflector annulus is kept in abeyance and awaiting future experiments and irradiations. Proposals from various users of these facilities are under review.

We look forward to another 15 years of intensive utilisation of CIRUS.

# α-CALCIUM SULPHATE HEMIHYDRATE AS BONE SUBSTITUTE

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Materials Processing Division

***Abstract***

*The use of calcium sulphate externally on the human body in the form of Plaster of Paris (PoP) has been well established, but its possible use inside the human body as bone void filler is a recent phenomenon. It has been realized that the quality of the calcium sulphate and its physical characteristics are the key factors for its reproducible performance inside human body, and most commercial powders may not be suitable. Controlling the size and shape of the calcium sulphate hemihydrate/bihydrate crystals is necessary to obtain a product, which will get resorbed in human body at a rate consistent with the new bone growth.*

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*It has been realised that α-hemihydrate form of calcium sulphate is a more suitable material for such applications. Hence α-hemihydrate of calcium sulphate was prepared in the laboratory and ceramic shapes with requisite porosity and strength were fabricated. The powders and pellets were characterised for their morphology and microstructure respectively. These shapes after radiation sterilisation have been used in certain test cases for orthopaedic surgery patients with bone defects. These trials have met with considerable success. Results obtained during the actual trials at L.T.M.G. Hospital, Mumbai, are described below.*

## Introduction

Bone defects secondary to trauma, osteomyelitis or after treatment of bone cysts or benign tumors are conventionally treated with autogenous bone graft. The autogenous, cancellous bone graft from the iliac crest has been considered the gold standard for the last fifty years. Although considered as the ideal graft material, cancellous bone is sometimes not available in sufficient quantity, and harvesting has its own potential complications of pain, blood loss, and infection (increased operative time) and donor site morbidity. These reasons justify continued efforts to find and use effective artificial substitutes for bone graft.

Calcium sulphate has been a familiar material in the medical field in its popular form of Plaster of Paris (PoP). It has been used since long as the sole material for setting of fractures in human body. The fracture zone is immobilised by its setting reaction initiated by its wetting and subsequent conversion to a strong cement like material. Because of this immobilisation, the fracture undergoes a natural healing process without any stress, which is necessary for repair of the fracture.

Such use of calcium sulphate externally on the human body has been well established and universally accepted. Very little was known about its possible use inside the human body till recent time. Historically, some attempts have been made to use calcium sulphate internally as bone void filler[1-4] and also as a carrier of antibiotic drug for the treatment of infected bone defects, due to its uniform elution kinetics[5,6].

It has been realised that the quality of the calcium sulphate and its physical characteristics are the key factors for its reproducible performance inside the human body. It was found that by controlling the size and shape of the calcium sulphate hemihydrate crystals of medical grade, it was possible to obtain a product which can get resorbed in the human body at a rate consistent with the new bone growth[7]. Such material offers a framework into which the bone of the patient can grow. It has been found to dissolve in vivo within 4-8 weeks depending on the volume and location of the infected site [8,9]. Thus, the biocompatibility, tolerance by the tissues and resorption of calcium sulphate have been reasonably established. In addition, the dissolution of calcium sulphate produces an acidic microenvironment (pH ~5.6) that may help limit the bacterial activity in the affected zone.

Commercially available products marketed after US FDA approval are now being used for surgical intervention inside human body. One such trademark product is “Osteoset” which comes in the form of pellets sterilised with gamma irradiation. Medical fraternity in India has been entirely dependent on imports of their requirement of such material. This work is aimed at developing a suitable calcium sulphate ceramics.

Calcium sulphate hemihydrate can be produced mainly in two varieties – beta form and alpha form. β-hemihydrate comprises of irregularly shaped crystals. It is relatively soft, has high porosity and short setting time, while α-hemihydrate has smooth regular acicular shaped denser particles. It has low porosity, longer setting time and develops higher compressive and tensile strength values after setting. Because of these properties, α-hemihydrate possesses a slower, more predictable solubility and resorption. Therefore, it is considered to be a more suitable material for orthopaedic applications because its resorption characteristics are found to be consistent with the bone growth rate.

## Experimental

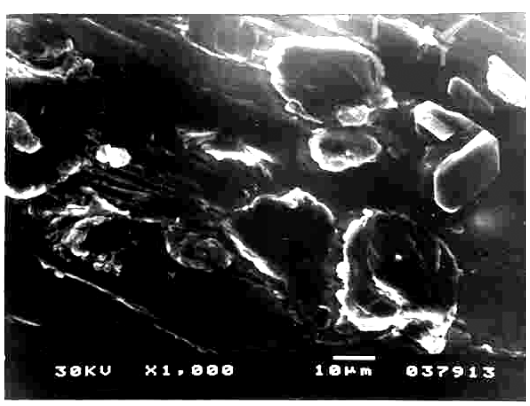
$\alpha$-hemihydrate can be produced either by (i) autoclave method, or (ii) hydrothermal method. The autoclave method employs heating of calcium sulphate bihydrate in an autoclave to temperatures above 100°C. Hydrothermal method consists of treating the bihydrate with aqueous solution of salts or inorganic acids at atmospheric pressure with or without boiling. In the present work, hemihydrate was prepared by dehydration of calcium sulphate bihydrate in dilute sulpuric acid.

Initially, several experiments were conducted to optimise the $CaSO_4.2H_2O$ / $H_2SO_4$ ratio and also the dilution of $H_2SO_4$. From the results of these experiments, a ratio of 20 g of bihydrate to 80 ml of 4N $H_2SO_4$ was arrived at. 80 ml of 4N $H_2SO_4$ was heated to 80°C in a continuously stirred bath and 20 g of bihydrate was added to it. The dehydration was allowed to proceed for 10 and 20 min. The product was filtered and washed with nearly boiling water to remove sulphuric acid. The resultant material was then dried at 105°C for six hours. Pellets (5mm $\phi$ x 5mm ht.) of requisite density (1.64 -1.72 $g.cm^{-3}$) were then fabricated. Powders as well as the pellets were examined under SEM for their morphology. The powder and pellets were radiation sterilised prior to use as bone void filler.

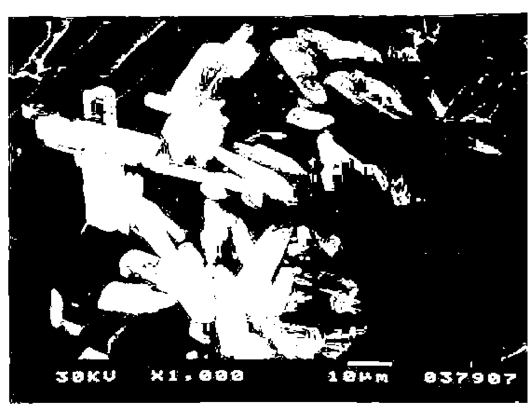
## Results and Discussion

Regeneration of the bone requires osteoconduction and osteoinduction activities. Osteoconduction is the property of the material to serve as a scaffolding for bone ingrowth while osteoinduction is referred to as its ability to induce mesenchymal cells to differentiate into osteoblasts by various biological signals. Hence, a good bone graft substitute should be osteogenic, biocompatible and bioresorbable. It should provide good structural support and should be amenable to easy handling. $\alpha$-calcium sulphate hemihydratte fulfills most of these requirements. It is osteoconductive and acts as a passive scaffold. It attracts ingrowth of fibrovascular tissue, leading to subsequent bone deposition.

SEM micrographs of hemihydrate powder, prepared after dehydration for 10 min and 20 min (labeled as DCS-10 and DCS-20 respectively) are shown in Figures 1(a) and (b). Powder DCS-10 shows round fluffy particles with wide variation in size. A few acicular particles can be seen indicating the onset of formation of $\alpha$-hemihydrate. In contrast, the conversion to $\alpha$-hemihydrate is nearly complete in DCS-20 and regularly shaped dense acicular particles with more uniform size distribution are obtained.




*(a)*




*(b)*

*Fig. 1 SEM micrograph of (a) DCS-10 and (b) DCS-20 powders*

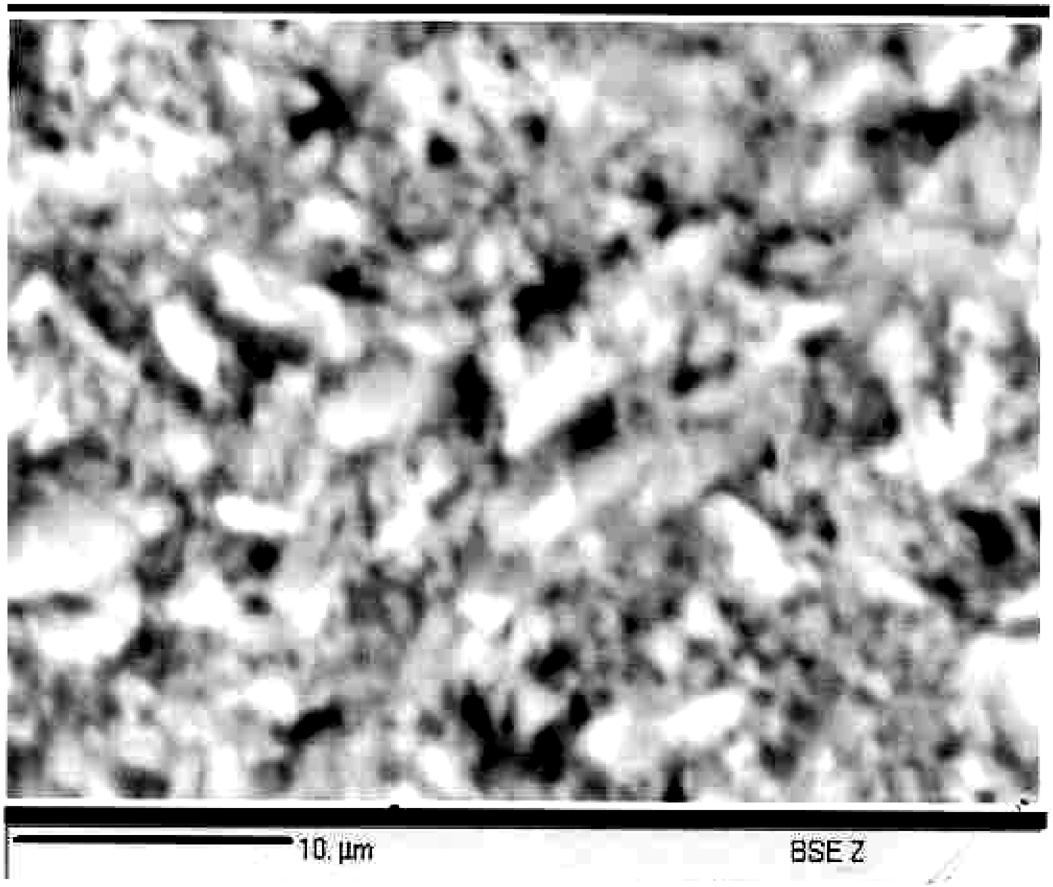


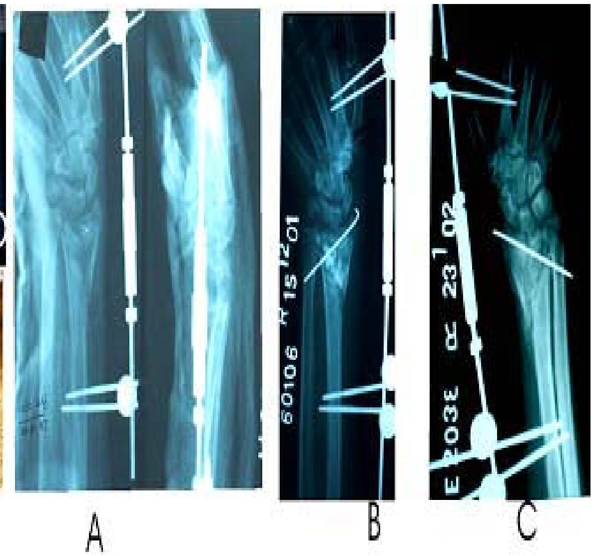

*Fig.2 SEM micrograph of DCS-20 pellet (bulk density 1.64 -1.72 g $cm^{-3}$)*

DCS-20 powder was compacted to obtain pellets of size 5mm $\phi$ x 5mm ht. with a bulk density of 1.64 -1.72 g $cm^{-3}$. This density range has been optimised for the pellets to have sufficient mechanical strength to withstand subsequent handling as well as an open porosity of ~25-30% to facilitate the ingrowth of bone. SEM micrograph of the surface of pellet from DCS-20 powder is shown in Figure 2.

$\alpha$-calcium sulphate hemihydratte powders and pellets were sealed in polythene and were sterilised by gamma irradiation. The sterilised material was used in clinical trials at Department of Orthhopaedics, L.T.M.G. Hospital, Mumbai. They created an implant composed of hemihydrate cement with antibiotics. The result of sustained release testing in vivo demonstrated the release of effective antibiotic concentrations over a period of three weeks. It was a bone filling material which allowed high concentration of antibiotics that acted locally, and allowed bone formation at the same time.

Initial experience in ten patients is discussed. These patients had bone cavity defect due to osteomyelitis, or secondary to trauma. All patients were treated according to their primary pathology and subsequent bone defects were filled with antibiotics impregnated $\alpha$-calcium sulphate hemihydrate pellets and small quantity of autologous bone graft. Patients were followed-up till the restoration of bone continuity. The average follow-up was more than six months. No adverse metabolic response was noted. In our experience with $\alpha$-calcium sulphate hemihydrate as bone graft substitute, we found the results encouraging. It is an ideal material for treating osteomyelitis, bone defect as a filler and also as a drug carrier device.


A : Cavity in tibia
B : Flap cover to close the defect
C,D : Pre Op. X-ray AP and lateral view
E,F : Post Op. x-ray
G,I : Post Op. clinical picture




Fracture lower end of radius
Communicated external fixator done
A : Intra Op. with fixator
B : Post Op. with $CaSO_4$ hemihydrate
C : Six weeks follow up – new bone formation in the defect

## Conclusion

$\alpha$-calcium sulphate hemihydrate powder was prepared in the laboratory after optimizing the dehydration parameters using dilute sulphuric acid. Pellets with requisite strength and porosity were fabricated and sterilized through gamma irradiation. The sterilized ceramics was used in clinical trials, which have met with considerable success.

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# NEUTRON SPECTROMETER

Centre for Design and Manufacture has designed and manufactured a Neutron Spectrometer for Inter University Consortium (IUC), Mumbai Center. This will be installed at Dhruva and will be used for conducting experiments using Neutron Beam, such as inelastic neutron scattering measurements, study of the structure of atom/molecules and elementary excitation like phonons or magnons in condensed matters. This is a P.C.-controlled mechanical instrument.

*Fig.1 Assembly of Neuron Spectrometer*

*Fig.2 Neutron Spectrometer after rotation*

This neutron spectrometer has two axes and one detector. Both the axes are having $\theta$ & $2\theta$ rotational stages. The first axis known as sample axis is stationary and is mounted on a bracket. The second axis known as analyser axis is mounted on the cantilever attached to the $2\theta$ rotational stage of 1st axis. Similarly, detector is mounted on another cantilever attached to $2\theta$ rotational stage of 2nd axis.

Rotational range of $\theta$ table for both axes is 0 to 360° with a resolution of 0.001° and repeatability of 0.005°. Rotational range of $2\theta$ table is 0° to 120° and 0° to 150° for 1st axis & 2nd axis respectively with resolution of 0.001° & repeatability of 0.005°. Provision has been made for analyser axis and detector to move radially towards and away from the centre position for the accurate positioning of analyser axis and detector with respect to sample axis and analyser axis respectively. Performance test of the instrument has been completed in the presence of IUC personnel and found satisfactory.

# राजभाषा कार्यान्वयन समिति, भाभा परमाणु अनुसंधान केंद्र, तारापुर, की "हिंदी माह - 2003" की रिपोर्ट

राजभाषा कार्यान्वयन समिति, भाभा परमाणु अनुसंधान केंद्र, तारापुर, ने इस वर्ष हिंदी माह मनाने का निर्णय लिया था। इस "हिंदी माह - 2003" में समिति ने हिंदी के प्रचार एवं प्रसार हेतु अनेक कार्यक्रमों का आयोजन किया था। इन कार्यक्रमों जि, के अंतर्गत समिति ने विभिन्न प्रतियोगिताएँ, स्वास्थ्य विषयों से संबंधित वार्तायें, प्रशासनिक कर्मचारियों के लिए एवं हेल्पर एवं ट्रैडसमन वी तक कर्मचारियों के लिए "तारापुर के संयंत्रों से परिचय" विषय पर एक दिवसीय संगोष्ठियों, आदि का आयोजन किया था।

जिसका विवरण निम्न है :

### 1.0 "हिंदी माह - 2003" का उद्घाटन समारोह

राजभाषा कार्यान्वयन समिति, भाभा परमाणु अनुसंधान केंद्र, तारापुर, ने तारापुर स्थित समस्त इकाइयों द्वारा संयुक्त रूपसे दिनांक 12/09/2003 से 24/10/2003 तक "हिंदी माह - 2003" मनाया। इस "हिंदी माह - 2003" का उद्घाटन समारोह दिनांक 12 सितम्वर 2003 को 11:00 बजे एल.डब्ल्यू.टी.पी. व्याख्यान कक्ष में किया


*हिंदी माह –2003 के उद्घाटन समारोह के अवसर पर मंच पर आसीन बायें से दायें - श्री राजेन्द्रसिंह गु. येवतीकर, अध्यक्ष, राजभाषा कार्यान्वयन समिति, तारापुर; श्री पी.जनार्दन, अधीक्षक, ईंधन पुनर्ससाधन संयंत्र, तारापुर; अजय मिश्रा, उप निदेशक, नाभिकीय पुनर्चक्र परियोजनाए, तारापुर; डा. जोस पनक्कल, संयंत्र अधीक्षक, प्रगत ईंधन संविरचन सुविधा, तारापुर; डा. शरद पी. काले, वरिष्ठ वैज्ञानिक अधिकारी, भाभा परमाणु अनुसंधान केंद्र, मुंबई एवं श्री आर. डी. सिंह, कमांडंट, केंद्रीय औद्योगिक सुरक्षा बल, तारापुर ।*

गया। इस समारोह में मुख्य अतिथि थे, डा. शरद पी. काले, वरिष्ठ वैज्ञाानिक अधिकारी, भाभा परमाणु अनुसंधान केंद्र, मुंबई एवं अन्य अतिथि थे, डा. एस. के. जैन, चिकित्सालय अधीक्षक, तारापुर परमाणु बिजलीघर अस्पताल, डा. जे. पी. पनक्कल, सयंत्र अधीक्षक, प्रगत ईंधन संविरचन सुविधा, तारापुर, श्री पी. जनार्दन, संयंत्र अधीक्षक, ईंधन पुनर्ससाधन संयंत्र, तारापुर, श्री अजय मिश्रा, उप निदेशक, नाभिकीय पुनर्चक्र परियोजनाएं, तारापुर, श्री आर. डी. सिंह, कमांडंट, केंद्रीय औद्योगिक सुरक्षा बल, तारापुर, एवं श्री आर. के. कुलकर्णी, वैज्ञानिक अधिकारी, भाभा परमाणु अनुसंधान केंद्र, मुंबई। अतिथियों के सभागार में प्रवेश करने के पश्चात सर्वप्रथम राजभाषा कार्यान्वयन समिति के सदस्यों ने उनका पुष्पगुच्छ देकर स्वागत किया। तत्पश्चात मुख्य अतिथि एवं अन्य अतिथियों ने वागदेवी माँ सरस्वती के चित्र पर मार्ल्यापण किया एवं दीप प्रज्वलित किया। श्री विजयकुमार लक्ष्मणराव कोरा ने सरस्वती वंदना की। इसके उपरान्त श्री राजेन्द्रसिंह गु. येवतीकर, अध्यक्ष, राजभाषा कार्यान्वयन समिति, तारापुर, ने अध्यक्षीय भाषण दिया। उन्होने "हिंदी माह - **2003**" क्यों मनाया जा रहा है और हिंदी को बढावा देने के लिए सारे कर्मचारियों का सहयोग एवं सहभाग किस तरह चाहिए इस पर विस्तृत जानकारी दी। अध्यक्ष ने इस माह में होने वाले कार्यक्रमों की भी जानकारी दी और लोगो से सभी प्रतियोगितायों में एवं अन्य कार्यक्रमों में सक्रिय रूप से भाग लेने के लिए अपील की। अतिथियों ने अपने भाषण में "हिंदी माह - **2003**" मनाने के लिए समिति के प्रयासों की सराहना की एवं हिन्दी को बढ़ावा देने के लिए क्या प्रयास करने चाहिए इस पर अपने विचार रखे।

इस कार्यकम में उद्घाटन समारोह के उपरान्त डा. शरद काले ने "सूक्ष्म जिवाणु, उनकी उपयोगिता एवं जैविक कचरा व्यवस्थापन में उनका महत्व" विषय पर रोचक व्याख्यान दिया। उन्होने बताया कि हम अपने घरों के रसोई घर से निकलने वाले कचरे एवं घास–फूस कचरे से किस तरह रसोई के लिए गैस एवं पौधों के लिए खाद का उत्पादन कर सकते हैं । इस तरह कचरा, कचरा न रह कर मूल्यवान वस्तु बन जाता है। उन्होने बताया कि सूक्ष्म जीवाणु कभी आराम नही करते, न ही अवकाश लेते हैं। डा. काले के व्याख्यान के बाद डा. कुलकर्णी ने भी विकृति विज्ञान के सम्बंध में विस्तृत जानकारी दी।

## 2.0 प्रतियोगिताएँ

राजभाषा कार्यान्वयन समिति, भाभा परमाणु अनुसंधान केंद्र, तारापुर, ने हिंदी के प्रचार एवं प्रसार हेतु इस वर्ष भी विभिन्न प्रतियोगिताओं का आयोजन किया था। इन प्रतियोगिताओं का विवरण निम्नलिखित हैं ः

| दिनांक | कार्यक्रम | आयोजन स्थल | समय |
|---|---|---|---|
| **1** अक्तूबर **2003** | समस्या पूर्ति प्रतियोगिता | एल.डब्ल्यू.टी.पी. व्याख्यान कक्ष | **15:15** बजे |
| **6** अक्तूबर **2003** | शब्द पहेली (cross word) प्रतियोगिता | प्रिफ्रि प्रशिक्षण कक्ष | **15:15** बजे |
| **10** अक्तूबर **2003** | भाषांतर और श्रुतलेखन प्रतियोगिता | ए.एफ.एफ.एफ. ग्रंथालय | **15:15** बजे |
| **14** एवं **15** अक्तूबर **2003** | प्रश्नमंच प्रतियोगिता | एल.डब्ल्यू.टी.पी. व्याख्यान कक्ष | **11:00** बजे |

**2.1** प्रथम प्रतियोगिता थी "समस्या पूर्ति", जिसमें प्रतिभागी को दो चित्र दिये गये थे, जिनमें एक दूसरे से संबंधित समस्या थी। प्रतियोगिता के प्रतिभागिओं को चित्र वाचन, चित्रों में दी गई समस्या की खोज एवं समस्या के समाधान के आधार पर अंक दिये गये । दूसरी प्रतियोगिता थी, "शब्द पहेली (cross word) प्रतियोगिता"।इस प्रतियोगिता में लोगों के हिंदी शब्द ज्ञान को परखा गया। तीसरी प्रतियोगिता थी, "भाषांतर और श्रुतलेखन प्रतियोगिता"। इस प्रतियोगिता में प्रतिभागियों को अंग्रेजी हिदी अनुवाद एवं श्रुतलेखन के आधार पर जॉचा गया । चौथी प्रतियोगिता थी, "प्रश्नमंच प्रतियोगिता" । इसमें समान्य ज्ञान, तकनीकी एवं अन्य विषयों से संबंधित प्रश्न पूछे गये थे और उनमें से सही उत्तर का चुनाव प्रतिभागियों को करना था। यह प्रतियोगिता काफी सरल थी और लोकप्रिय रही।

***2.2*** इन प्रतियोगिताओं में राजभाषा कार्यान्वयन समिति एव केन्द्रीय सचिवालय हिंदी परिषद, तारापुर के सदस्यों ने संचालक के रूप में काम किया।निर्णायक गण थे भाभा परमाणु अनुसंधान केंद्र, तारापुर के वरिष्ठ अधिकारी।

### **3.0** एक दिवसीय संगोष्ठियां

इस हिंदी माह के दौरान दिनांक **13/ 10/2003** को तारापुर परिसर के विभिन्न स्तर के प्रशासनिक कर्मचारियों के लिए एवं दिनांक **20/10/ 2003** को हेल्पर एवं ट्रेडस्मैन वी तक के कर्मचारियों के लिए एक दिवसीय संगोष्ठिओं का आयोजन किया था। इन एक दिवसीय संगोष्ठिओं में "तारापुर स्थित संयंत्र परिचय" विषय पर वार्ताओं का आयोजन किया गया था।

इन संगोष्ठियों के उद्घाटन सत्र में उपस्थित तारापुर स्थित संयंत्रों के अध्यक्ष एवं वरिष्ठ अधिकारी गणों ने वागदेवी मॉ सरस्वती के चित्र पर माल्यार्पण करके दीप प्रज्वलित किया ओर संगोष्ठीओं का उदघाटन किया। इसके वाद राजभाषा कार्यान्वयन समिति, भाभा परमाणु अनुसंधान केंद्र, तारापुर, के अध्यक्ष, श्री राजेन्द्रसिंह गु. येवतीकर ने अपने अध्यक्षीय भाषण में सभी का स्वागत किया एवं संगोष्ठी के विषय-वस्तु का परिचय दिया।

इन संगोष्ठियों में श्री कौशल कुमार श्रीवास्तव ने इंधन पुर्न संसाधन संयंत्र के बारे में जानकारी दी।उन्होने भुक्त–शेष ईंधन से लेकर प्लूटोनियम एवं यूरेनियम के शुद्ध अवस्था तक आने के विषय में विस्तृत रूप से बताया। श्री रामहरख रा. सिंह ने प्लूटोनियम प्रयोगशाला के बारे में जानकारी दी कि प्लूटोनियम शुद्ध अवस्था तक आने में किन–किन चरणों से गुजरता है। श्री अमृत प्रकाश ने ईंधन संविरचन सुविधा संयंत्र की जानकारी दी कि किस तरह मिश्रित आक्साइड ईंधन का निर्माण किया जाता है।साथ ही उन्होने मिश्रित आक्साइड ईंधन की उपयोगिता के बारे में भी बताया। श्री नंदकुमार ल. सोनार ने अपशिष्ट प्रवंधन सुविधाएं , संयंत्रों की जानकारी दी और बताया की नाभिकिय क्षेत्र में अपशिष्ट प्रवंधन कितना महात्वपूर्ण है। श्री जोगेन्द्र रा. यादव ने स्वास्थ्य भौतिकी के विषय में बताया कि नाभिकीय क्षेत्रों में काम करनेवाले कर्मचारियों के स्वास्थ्य के बारे में क्या क्या सावधानियां ली जाती हैं साथ ही वातावरण एवं आस पास के क्षेत्र की मॉनिटरिंग कैसे करते है, यह भी बताया।

इन एक दिवसीय संगोष्ठीयों में विभिन्न संयंत्रों एवं सामान्य सेवाएं संगठन से दिनांक **13/10/2003** को करीब **40** प्रशासनिक कर्मचारियों ने और **20/10/2003** को करीब **50** हेल्पर्स एवं ट्रेडस्मैन ने भाग लिया।

### **4.0** स्वास्थ्य विषय पर वार्ताएं

दिनांक **17/10/2003** को स्वास्थ्य संबंधित विषयों पर भी वार्ताएं रखी गयीं। इसमें डा.श्रीमती रश्मि जैन ने हृदय से


*हिंदी माह –**2003** के समापन समारोह के अवसर पर मंच पर आसीन बाये से दाये - श्री यदुनाथ कुलकर्णी, अधीक्षक, अपशिष्ट प्रवंधन सुविधाए, पी.जनार्दन, अधीक्षक, ईंधन पुनर्ससाधन संयंत्र, तारापुर; डा. जोस पनक्कल, संयंत्र अधीक्षक, प्रगत ईंधन संविरचन सुविधा, तारापुर; मुख्य अतिथि श्री डे, परियोजना निदेशक, नाभिकीय पुनर्चक्र परियोजनाए, तारापुर, एवं अध्यक्ष, ईंधन पुनर्ससाधन प्रभाग; श्री आर. डी. सिंह, कमांडंट, केंद्रीय औद्यो बल, तारापुर एवं श्री राजेन्द्रसिंह गु. येवतीकर, अध्यक्ष, राजभाषा कार्यान्वयन समिति, तारापुर।*

संबंधित बीमारियों एवं हृदय को कैसे स्वस्थ रखा जाये इस पर बहुत ही रोचक जानकारी दी। डा.रजनीकांत एम. वानखेडे ने विकृति विज्ञान पर वार्ता दी, साथ ही "ब्लड बैंक" कैसे कार्य करता है इसकी भी जानकारी दी। डा. कुलदीप सिंह ने दंत चिकित्सा पर वार्ता दी। उन्होने लंबे समय तक दातों को कैसे स्वस्थ रखा जाये उन उपायों के बारे में भी बताया।

**5.0 हिंदी माह 2003 का समापन समारोह**

**24** अकतूबर **2003** को "हिंदी माह–**2003**" का समापन किया गया। उसी दिन विजेता प्रतिभागियों को पुरस्कार वितरण किया गया। इस पुरस्कार वितरण एवं समापान समारोह के मुख्य अतिथि थे, परियोजना निदेशक, नाभिकीय पुनर्चक्र परियोजनाए, तारापुर, एवं अध्यक्ष, ईंधन पुनर्ससाधन प्रभाग, श्री प्राण कृष्ण डे। श्री प्राण कृष्ण डे ने "हिंदी माह–**2003**" के सफलतापूर्वक आयोजन के लिए राजभाषा कार्यान्वयन समिति, तारापुर, की सराहना की एवं लोगों से हिंदी में अधिक से अधिक काम करने की अपील की।

# IAEA/RCA REGIONAL TRAINING COURSE ON EXPERIMENTAL RESEARCH REACTOR PHYSICS

The IAEA-RCA Regional Training Course for Asia-Pacific Region on "Experimental Research Reactor Physics" was conducted at Hotel Days Inn, Vashi, Navi Mumbai, during March 15-26, 2004. The training course was sponsored by IAEA and organised by Reactor Group, BARC.

Twelve foreign participants and twelve national participants attended the course. Two participants each from Bangladesh, China, Indonesia, Malaysia and Vietnam and one participant each from Thailand and Korean Republic attended the training course.


*Mr B. Bhattacharjee, Director, BARC, inaugurating the IAEA/RCA Regional Training Course.*

The training course consisted of twelve regular lectures and five special lectures. Each lecture session was of one and half hour duration including a discussion time of 15 -20 minutes. A regular lecture covered one session while each special lecture was spread over two sessions. The topics for the regular lectures included basic subjects like Nuclear Instrumentation for Reactor Startup and Power Regulation, Physics Aspects of Reactor Startups, Lattice and Core Calculations, Nuclear Reactor Kinetics and Neutron Flux and Spectrum Measurements. Topics for the special lectures were Fast Reactor Physics, Shielding Experiments in APSARA, Design Features of Multi-Purpose Research Reactor (MPRR) & APSARA Reactor Core Conversion and Physics Design Validation of the Advanced Heavy Water Reactor through Experiments in a Critical Facility. From the angle of topical interest, a special lecture on Refurbishment of CIRUS Reactor was also presented. Pre-print of the lecture notes was published in advance and was distributed to the participants on the first day of the training course. In addition to the lecture programme, the training course included sessions on demonstration of use of computer codes for steady state and dynamic analysis of nuclear reactor cores, practical and demonstration of approach to criticality including sub-critical measurements, reactivity related measurements and flux measurements. The training programme also included technical visits to the research reactor facilities APSARA, CIRUS and DHRUVA at BARC, Trombay. Nine foreign participants and two national participants made interesting presentations regarding research reactor related activities in their respective countries.

On the afternoon of the last day of the training course, a feedback sesssion was held wherein the participants were asked to give their response through the questionnaire received from IAEA. The overall response of the participants regarding all aspects of the training course was extremely positive.

Mr B Bhattacharjee, Director, BARC, inaugurated the training course on March 15, 2004. Mr S.K. Sharma, Vice Chairman, Atomic Energy Regulatory Board, formally released the compilation of the lecture notes during the inaugural function. Dr S.K. Paranjpe, Technical Officer, IAEA, presented the keynote address. Mr S. Sankar, Director, Reactor Group, BARC, and Mr K. Raghuraman, National RCA Representative, were also present among others during the training course inauguration. Mr R. Chowdhury, Associate Director, Reactor Group, BARC, presided over the valedictory function on March 26, 2004.

# BARC TRANSFERS KNOW-HOW OF "FDK-FLUORIDE DETECTION KIT FOR GROUNDWATER"

The know-how of "FDK-fluoride detection kit for groundwater" has been developed by National Centre for Compositional Characterization of Materials (CCCM), BARC, Hyderabad. The kit is meant for use in the field by a common man without dependence on any laboratory equipment for testing and is highly cost-effective to produce. This field-kit is based on a visual colorometric method utilising a specially developed reagent for this purpose. There is an ever-rising need for a simple kit of this nature in the country as a large number of groundwater sources are found to be fluoride contaminated. The testing procedure is as simple as adding 1 ml of the reagent to 4 ml of groundwater sample and identifying the color developed with the naked eye. The color develops instantaneously and is highly stable. Thus, a groundwater source can be immediately categorised as being safe, marginal or unsafe for drinking from fluoride point of view. The raw materials required for producing this kit are available within the country.

*Photograph after signing the agreement with M/s. LTEK Systems, Nagpur. Seen from left to right are Mr A.M. Patankar, Head, TT&CD, Mr B.K. Pathak, TT&CD, Mr Rahul Dhabu, LTEK Systems, Dr C.L. Lakhotia, LTEK Systems, Dr S.C. Chaurasia, CCCM, Dr R.B. Grover, Director, KMG, BARC, and Dr T. Mukherjee, Associate Director, Chemistry Group, BARC*

The know-how of "FDK-fluoride detection kit for groundwater" was transferred to M/s. LTEK Systems, Nagpur, on June 17, 2004.

Technology Transfer and Collaboration Division, BARC, coordinated all activities related to the transfer of this technology, such as preparation of Technical Brochure, Technology Transfer Document, Advertisement of the Technology, Technology Transfer Agreement preparation and the signing of Agreement in collaboration with CCCM, Hyderabad.

# DAE THEME MEETING ON APPLICATIONS OF MONTE CARLO IN MEDICAL DOSIMETRY, SHIELDING CALCULATIONS AND REACTOR SAFETY

A one-day theme meeting on the 'Applications of Monte Carlo in Medical Dosimetry, Shielding Calculations and Reactor Safety, was organised by the Health & Safety Group, BARC, on March 4, 2004 at the Health Physics Auditorium, CT&CRS Building, Anushaktinagar, Mumbai. Mr H.S. Kushwaha, Director, HS&E Group, BARC, inaugurated the meeting. Dr B.C. Bhatt, Head, RP&AD, BARC, described briefly the scope of the meeting. Mr S.K. Gupta, RP&AD, was co-ordinator of this meeting. The aim of the meeting was to stimulate closer interaction among MC users and motivation for new workers in the field.

The meeting was attended by about 60 participants from several DAE units. Dr P.S. Nagarajan and Mr M.A. Prasad, both ex-BARC experts in the field of Monte Carlo were invited to give plenary talks and necessary guidance to the new entrants in the field of Monte Carlo computations. Plenary lecturers were also delivered by Dr P.K. Sarkar, RSSD, BARC, Dr K.V. Subbaiah, SRI, AERB and Mr S.K. Gupta, RP&AD, BARC. There were 12 oral presentations by the participants. The meeting concluded with a panel discussion. Mr H.S. Kushwaha, Director, HS&E Group, BARC, chaired the panel discussion. The other members present on the dais were Dr B.C. Bhatt, Head, RP&AD, Dr P.S. Nagarajan, Mr M.A. Prasad and Dr K.V. Subbaiah. Participants felt a need for procurement of updated versions of Monte Carlo code systems, particularly MCNP from the countries where these codes have been developed. Panel members, however, provided useful guidance to the participants on problems relating to MC simulations. It was also agreed that periodic meetings of this nature at an interval of about six months would greatly improve the standard and scope of the work and would attract more and more participants in the field.

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

• डॉ. श्रीकुमार बॅनर्जी, हाल में ही नियुक्त भा.प.अ. केंद्र, के निदेशक, विभिन्न पुरस्कारों एवं सम्मानों के प्राप्तकर्ता हैं जिनमें इंजीनियरिंग साइंसेज में शान्ति स्वरूप भटनागर पुरस्कार (1989), जी.डी. बिरला गोल्ड मेडल ऑफ द इन्डियन इन्सटिट्यूट ऑफ मेटल्ज़ (1997), आइ एन एस ए प्राइज़ फॉर मेटीरियल साइन्स (2001), एवं द एक्टा मेटालर्जिका आउटस्टेंडिंग पेपर अवार्ड (1984) भी शामिल हैं। हाल ही में इन्होंने मेटीरियल साइन्स के कार्यक्षेत्र में उत्कृष्ट योगदान

के लिए प्रतिष्ठापूर्ण हुमबोल्ट रिसर्च पुरस्कार प्राप्त किया। इस पुरस्कार में 50,000 यूरो की राशी तथा एक प्रशस्ति-पत्र निहित है।

Dr Srikumar Banerjee, the newly appointed Director of BARC, is the recipient of several awards and honours which include the Shanti Swaroop Bhatnagar Award in Engineering Sciences(1989), G.D. Birla Gold Medal of the Indian Institute of Metals (1997), INSA Prize for Materials Science (2001), and the Acta Metallurgica Outstanding Paper Award (1984). Recently, he received the prestigious Humboldt Research Award for his outstanding contributions in the frontline areas of materials science. The award comprises a cash amount of Euro 50,000/- and a citation.

• डॉ. जय पाल मित्तल, को भी विकिरण एवं फोटो रसायनिकी एवं लेज़र के क्षेत्र में प्रमुख योगदान के लिए वर्ष 2003 में प्रतिष्ठापूर्ण हुमबोल्ट रिसर्च पुरस्कार से सम्मानित किया गया है। इनकी योग्यता रसायन गतिविज्ञान एवं लेज़र रसायनिकी के क्षेत्र में कई जर्मन वैज्ञानिक वर्गों तथा भारतीय वैज्ञानिकों के परस्पर सहयोग अनुसंधान परियोजना में फलप्रद सिद्ध हुई।


Dr Jai Pal Mittal, was also awarded the prestigious Humboldt Research Award in 2003 for his contribution in the areas of radiation and photochemistry and laser chemistry. His leadership qualities resulted in many fruitful collaborative research projects between a number of German scientific groups and Indian scientists in the areas of Chemical Dynamics and Laser Chemistry.

• डॉ. आर.मुखोपाध्याय, ठोस अवस्था भौतिकी प्रभाग, भाभा परमाणु अनुसंधान केंद्र, को टेलर एवं फ्रंसिस के द्वारा प्रकाशित न्यूट्रान स्केटरिंग इन्सट्रूमेन्टेशन एन्ड एप्लिकेशन ऑफ न्यूट्रान स्केटरिंग टेक्नीक फॉर कन्डेन्स्ड मेटर रिसर्च के क्षेत्र में विशिष्ठ योगदान को मान्यता देने के लिए एक प्रसिद्ध अन्तर्राष्ट्रीय पत्रिका के संपादकीय मंडल का सदस्य नामांकित किया गया है। इस पत्रिका में इंजीनियरिंग साइन्स, न्यूट्रान इन्सट्रूमेन्टेशन एन्ड टेक्नीक्स, एवं रियक्टर ऑर स्पालेशन सोर्स टेक्नालोजी जैसे तीन क्षेत्रों के प्रयोगात्मक तथा सैद्धान्तिक मौलिक गुण प्रकाशित किए जाते हैं।

Dr R. Mukhopadhyay of Solid State Physics Division, BARC, has been nominated as member of the Editorial Board of the reputed International journal, *Journal of Neutron Research,* published by Taylor & Francis, in recognition of his excellent contribution in the field of neutron scattering instrumentation and application of neutron scattering technique for condensed matter research. The journal publishes original research papers of experimental and theoretical nature in three areas of specialization in neutron research : Engineering Science, Neutron Instrumentation and Techniques, and Reactor or Spallation Source Technology.

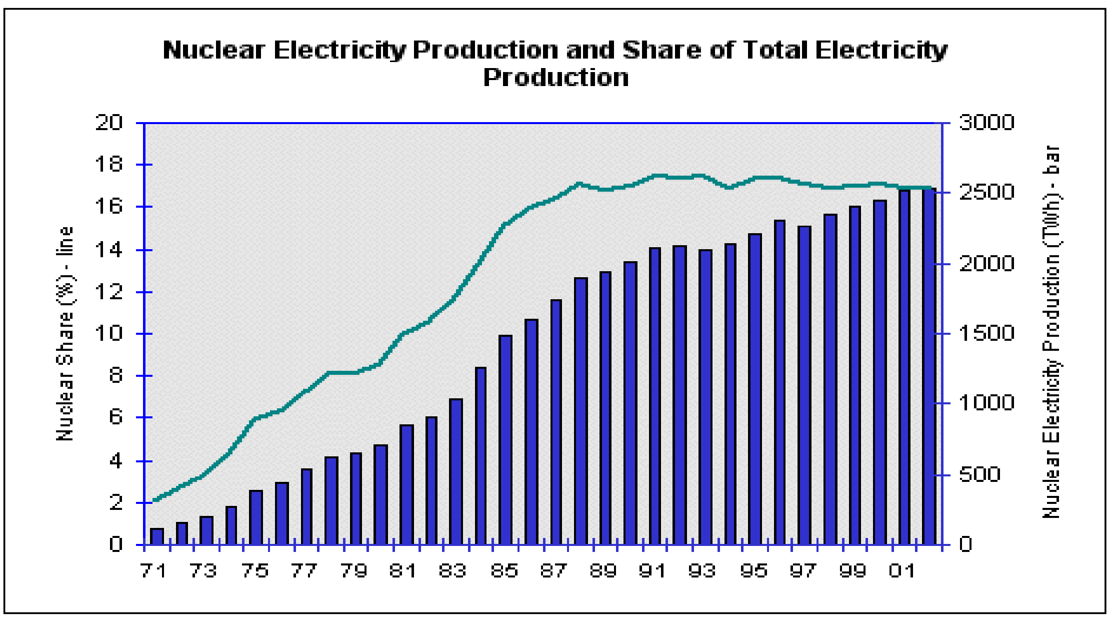
• डॉ. सोना सक्सेना, पाँचवें बैच के के.एस. कृष्णन शोध सहयोगी, नाभिकीय कृषि एवं जैव प्रौद्योगिकी प्रभाग, भाभा परमाणु अनुसंधान केंद्र में कार्यरत, को फरवरी 25-26, 2004 में नेशनल इन्सटिट्यूट ऑफ ओशनोग्राफी, डोना पौला, गोआ, के सहयोग से इन्टरनेशनल वाटर एसोसिएशन, यू.के. द्वारा आयोजित मेरीन पोल्यूशन एवं इकोटोक्सीकोलोजी की अन्तर्राष्ट्रीय कार्यशाला में सोना सक्सेना तथा एस.एफ. डि'सूज़ा के द्वारा प्रस्तुत "हेव्वी मेटल पोल्यूशन अबेटमेन्ट यूज़िन्ग रॉक फोसफेट मिनरल" नामक शोधपत्र के लिए बेस्ट पोज़र पुरस्कार से सम्मानित किया गया है ।

Dr Sona Saxena, a K.S. Krishnan Research Associate 5th batch, working in Nuclear Agriculture and Biotechnology Division, BARC, was awarded the best poser award for her paper titled, "Heavy metal pollution abatement using rock phosphate mineral", by Sona Saxena and S.F. D'Souza, presented in International Workshop on Marine Pollution and Ecotoxicology, February 25-26, 2004, organised by National Institute of Oceanography, Dona Paula, Goa, in collaboration with International Water Association, U.K.

# NUCLEAR POWER IN THE WORLD TODAY

Today, the world produces as much electricity from nuclear energy as it did from all sources combined in 1960. Civil nuclear power can now boast over 11,000 reactor years of experience and supplies 16% of global needs. Many countries also built research reactors to provide a source of neutron beams for scientific research and the production of medical and industrial isotopes.

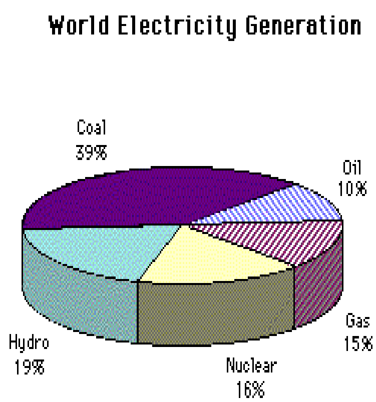
Today, 56 countries operate civil research reactors, and 31 have some 440 commercial nuclear power reactors with a total installed capacity of over 3,60,000 MWe (see Table). This is more than three times the total generating capacity of France or Germany from all sources. More than 30 further power reactors are under construction, equivalent to 7% of existing capacity, while a similar number are firmly planned, equivalent to 10% of present capacity.



Seventeen countries depend on nuclear power for at least a quarter of their electricity. France and Lithuania get around three quarters of their power from nuclear energy, while Belgium, Bulgaria, Hungary, Japan, Slovakia, South Korea, Sweden, Switzerland, Slovenia and Ukraine get one third or more.

## Improved Performance from Existing Reactors

Although fewer nuclear power plants are being built now than during the 1970s and 1980s, those now operating are producing more electricity. In 2002, production was 2574 billion kWh, an increase of 1% (30 TWh) over the previous year.




The increase over the last five years (298 TWh) is equal to the output from 40 large new nuclear plants. Yet, between 1997 and 2001, there was a net increase of only three reactors (2% in capacity). The rest of the improvement is due to better performance from existing units.

Almost two-thirds of the world's nuclear reactors have load factors of more than 80%, compared with less than a quarter of them in 1990. For 15 years, Finnish plants topped the performance tables, but Spain, Belgium, Switzerland and South Korea have now joined it in averaging over 90%.

US nuclear power plant performance has shown a steady improvement over the past 10 years, and the average load factor now stands at around 90%, up from 65% in 1990. This places the USA among the performance leaders with 13 of the top 23 reactors - achieving more than 98%. The USA accounts for nearly one third of the world¹s nuclear electricity.

In 2002, five of the top 23 plants were Japanese and Japan achieved an 77% average load factor, while French reactors averaged the same, despite being run in load-following mode, rather than purely for base-load power.

Some of these figures suggest near-maximum utilisation, given that most reactors have to shut down every 12-18 months for fuel change and routine maintenance. Another measure is unplanned capability loss, which in the USA has for the last four years been below 2%.

## Other Nuclear Reactors

In addition to commercial nuclear power plants, there are more than 280 research reactors operating in 56 countries, with more under construction. These have many uses including research and the production of medical and industrial isotopes, as well as for training.

The use of reactors for marine propulsion is mostly confined to the major navies where it has played an important role for four decades, providing power for submarines and large surface vessels. Over 150 ships are propelled by more than 200 nuclear reactors. The US Navy has accumulated over 5400 reactor-years of accident-free experience. Russia and the USA are now decommissioning many of their nuclear submarines. Russia also operates a fleet of eight large nuclear-powered icebreakers which are more civil than military.

## WORLD NUCLEAR POWER STATUS

| Country | Reactors in operation May 2004 | | Reactors under construction May 2004 | | Nuclear electricity supplied in 2002 | |
|---|---|---|---|---|---|---|
| | No of Units | Capacity MW(e) | No of Units | Capacity MW(e) | billion kWh | Nuclear Share (%) |
| Argentina | 2 | 935 | | | 5.4 | 7.2 |
| Armenia | 1 | 376 | | | 2.1 | 41 |
| Belgium | 7 | 5728 | | | 44.7 | 57 |
| Brazil | 2 | 1901 | | | 13.8 | 4.0 |
| Bulgaria | 4 | 2722 | | | 20.2 | 47 |
| | | | | | | |
| Canada | 17 | 12080 | 1 | 515 | 71.0 | 12 |
| China | 9 | 6587 | 2 | 1900 | 23.5 | 1.4 |
| Czech Republic | 6 | 3472 | | | 18.7 | 25 |
| Finland | 4 | 2656 | | | 21.4 | 30 |
| France | 59 | 63473 | | | 415.5 | 78 |
| | | | | | | |
| Germany | 18 | 20643 | | | 162.3 | 30 |
| Hungary | 4 | 1755 | | | 12.8 | 36 |
| India | 14 | 2493 | 9 | 4128 | 17.8 | 3.7 |
| Iran | | | 1 | 950 | | |
| Japan | 54 | 45521 | 3 | 3294 | 313.8 | 39 |
| Korea (North) | 0 | 0 | 1 | 950 | 0 | 0 |
| Korea, Republic of (South) | 19 | 15880 | 1 | 960 | 113.1 | 39 |
| | | | | | | |
| Lithuania | 2 | 2370 | | | 12.9 | 80 |
| Mexico | 2 | 1310 | | | 9.4 | 4.1 |
| Netherlands | 1 | 452 | | | 3.7 | 4.0 |
| Pakistan | 2 | 425 | | | 1.8 | 2.5 |
| Romania | 1 | 655 | 1 | | 5.1 | 10 |
| Russia | 30 | 20793 | 6 | 5475 | 130 | 16 |
| | | | | | | |
| Slovakia | 6 | 2472 | | | 18.0 | 65 |
| Slovenia | 1 | 676 | | | 5.3 | 41 |
| South Africa | 2 | 1842 | | | 12.0 | 5.9 |
| Spain | 9 | 7584 | | | 60.3 | 26 |
| Sweden | 11 | 9429 | | | 65.6 | 46 |
| Switzerland | 5 | 3220 | | | 25.7 | 40 |
| Taiwan | 6 | 4884 | 2 | 2600 | 33.9 | 21 |
| | | | | | | |
| UK | 27 | 12048 | | | 81.1 | 22 |
| Ukraine | 13 | 11268 | 2 | 1900 | 73.4 | 46 |
| USA | 103 | 97485 | 1 | 1065 | 780.1 | 20 |
| **Total** | 441 | 363135 | 30 | 23737 | 2574 | |

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