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
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

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CIRUS reactor structure cross section
- Epoxy grouting to make it a monolithic structure to meet safe shut down earthquake 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.
• 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.
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.

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**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 $\alpha$-hemihydrate form of calcium sulphate is a more suitable material for such applications. Hence $\alpha$-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. $\beta$-hemihydrate comprises of irregularly shaped crystals. It is relatively soft, has high porosity and short setting time, while $\alpha$-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, $\alpha$-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**

α-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 sulphuric acid.

Initially, several experiments were conducted to optimise the CaSO₄⋅2H₂O / H₂SO₄ ratio and also the dilution of H₂SO₄. From the results of these experiments, a ratio of 20 g of bihydrate to 80 ml of 4N H₂SO₄ was arrived at. 80 ml of 4N H₂SO₄ 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 φ 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. α-calcium sulphate hemihydrate 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 α-hemihydrate. In contrast, the conversion to α-hemihydrate is nearly complete in DCS-20 and regularly shaped dense acicular particles with more uniform size distribution are obtained.

*Fig. 1 SEM micrograph of (a) DCS-10 and (b) DCS-20 powders*
DCS-20 powder was compacted to obtain pellets of size 5mm $\phi \times 5$mm 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 hemihydrate powders and pellets were sealed in polythene and were sterilised by gamma irradiation. The sterilised material was used in clinical trials at Department of Orthopaedics, 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.
Conclusion

α-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.

References

**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.

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 \( \theta \) 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.

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**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 पुंजाब एवं पश्चिम हिंदुस्थान में अनेक कार्यक्रमों का आयोजन किया था। इन कार्यक्रमों जिनके अंतर्गत समिति ने विभिन्न पत्रिकाओं, स्वायत्त विषयों से संबंधित वाणी, प्राचीनकालीन कला-शिल्पों के लिए एवं हैट्लाल व ट्रेडसमन की तक कलाकारों के लिए “तारापुर के संस्थागत परिवर्त” विषय पर भी दिवसीय संगठित, आदि का आयोजन किया था। जियोग्राफ निम्न हैं:

1.0 “हिंदी माह - 2003” का उद्घाटन समारोह

राजभाषा कार्यान्वयन समिति, भाभा परमाणु अनुसंधान केंद्र, तारापुर, ने तारापुर शिखर समारोह द्वारा संबंधित समारोह 12/09/2003 में 24/10/2003 तक “हिंदी माह - 2003” मनाया। इस “हिंदी माह - 2003” का उद्घाटन समारोह दिनांक 12 सितंबर 2003 को 11:00 बजे एल.एडिसन टी.पी. व्यायाम कक्ष में किया
गया। इस समारोह में मुख्य अधिवेशन टे, डा. अर्दीते श्रड, का कारण वैज्ञानिक अधिकारी, भारत प्रधान अनुसंधान केंद्र, मुंबई एवं अन्य अधिवेशन थे। डा. एम. एम. जैन, विक्रमाशिनी अंधकार, तातापुर, भारत प्रधान विज्ञान अनुसंधान, डा. जे. पी. पालक, गंगा अंधकार, प्रगत ईथन संचार शिविर, तातापुर, श्री पी. जनार्दन, संग्रह अंधकार, ईथन पुनर्माध्यम संग्रह, तातापुर, श्री अजय मिश्रा, उप निदेशक, नामदेव कुलकारी, नामदेव पुनर्माध्यम संग्रह, तातापुर, श्री आर. डी. सिंधू, कमलेंड्र, कंदवी भौटिक शिविर, तातापुर, एवं श्री आर. डे. कुलकारी, वैज्ञानिक अधिकारी, भारत प्रधान अनुसंधान केंद्र, मुंबई।

अधिकारियों के समारोह में प्रेम करने के पश्चात वर्तमान राजमार्ग कार्यवाह समिति के सदस्यों ने उनका पुष्पकुशी देकर व्यवस्थित किया। तपस्यात्मक मुख्य अधिवेशन एवं अन्य अधिकारियों ने वांगदेशी मां सरकारी के विषय पर मार्गदर्शिका अधिकार एवं दीप ज्ञानकारी किया। श्री विजयजी संयुक्त लक्षण इंस्टीट्युट ने सरकारी बंदना की। इसके उपरान्त श्री राजनार्दणी श्रृंग. वैज्ञानिक, अंधकार, राजमार्ग कार्यवाह समिति, तातापुर, ने अध्यक्षीय भाषण दिया। उन्होंने "हिंदी माह - 2003" के बारे में बच्चों का जिक्र किया और हिंदी को बढ़ावा देने के लिए पांक कर्मचारियों का सहयोग एवं गहराई किस तरह चाहिए हम पर वित्त कर जानकारी दी। अध्यक्ष ने इस माह में भोजने वाले कार्यकर्ताओं को भी जानकारी दी और लोगों के सभी प्रतिभागियों में एवं अन्य कार्यकर्ताओं में मंकिय रूप से भाग लेने के लिए अपील की।

अधिकारियों ने अपने भाषण में "हिंदी माह - 2003" मनाने के लिए समिति के पपायों की गहराई एवं हिंदी को बढ़ावा देने के लिए कथ प्राप्त करने चाहिए इस पर अपने विचार रखे।

इस कार्यकर्ता में उद्योग समारोह के उपरान्त डा. अर्दीते श्रड, का कारण "सूचना जिवानु, उनकी उपयोगिता एंव वैज्ञानिक कसर व्यवस्थापन में उनकी महत्व" बारे पर रोचक व्यवहार दिया। उन्होंने बताया कि हम अपने दो घंटे के रोगों घंटे में निकलने वाले कर्मचारी के किस तरह रोग दर्ज कर सकते हैं इस तरह कर्मचारी, कर्मचार न रह कर मुल्यवान बन जाता है। उन्होंने बताया कि युवा नेता जीवन कभी आराम नहीं करते, न ही अवकाश लेते हैं। 

डा. कलेने के व्यवहार के बाद डा. कुलकारी ने भी विश्वसनीय विधान के समां में वित्त कर जानकारी दी।

2.0 प्रतिभागियों के प्रति अधिकारियों ने राजमार्ग कार्यवाह समिति, भारत प्रधान अनुसंधान केंद्र, तातापुर, ने हिंदी के पचार एवं प्रमाण हेतु इस वर्ष भी विभिन्न प्रतिभागियों का आयोजन किया था। इन प्रतिभागियों का विवरण निम्नलिखित हैं।
2.1 प्रथम पत्रियोगिता दी “समस्या पूर्णी”, जिसमें प्रतिभागी को दो विचार किए गए थे, जिनमें एक हूसरे से संबंधित समस्या थी। पत्रियोगिता के प्रतिभागियों को विचार वाचन, अंशों में दी गई समस्या की योजना एवं दस्तावेज के समाधान के आधार पर अंक दिये गये। दूसरी पत्रियोगिता थी, “शब्द पहली (cross word) पत्रियोगिता”। इस पत्रियोगिता में तीनों के हिस्से शब्द इन्हें परिभाषित किया गया।

2.2 इन पत्रियोगिताओं में राजभाषा कार्यान्वयन समिति एवं केंद्रीय संविधानलय हिंदी परिषद, तारापुर के उद्घाटन न शालक के स्थान ने संवाल के स्थान में काम किया। प्रत्येक गया थे भाषा प्रमाण अनुसंधान केंद्र, तारापुर के वरिष्ठ अधिकारी।

3.0 एक दिवसीय संगठनों

इस हिंदी मास के दौरान दिनांक 13/10/2003 को तारापुर परिषद के विभिन्न स्तर के प्राधिकरित कर्मचारियों के लिए एवं दिनांक 20/10/2003 को हेल्पर एवं ट्रेडमैन दो तक के कर्मचारियों के लिए एक दिवसीय संगठनों का आयोजन किया था। इस एक दिवसीय संगठनों में “तारापुर स्थित संस्थापरिचय” विषय पर बातचीत का आयोजन किया गया था।

इन संगठनों के उद्घाटन स्वतंत्र में उपस्थित तारापुर विभाग संस्थान के अध्यापक एवं वरिष्ठ अधिकारी गणना में वाहकों में संगठित की विचार पर माध्यम प्रसार करके दीप प्रसारित किया और संगठनों का उद्घाटन किया। इसके बाद राजभाषा कार्यान्वयन समिति, भाषा प्रमाण अनुसंधान केंद्र, तारापुर के अध्यापक, श्री राजेन्द्र सिंह स्वतंत्रता ने अपने अनुकूल भाषण में सभी को स्वागत किया एवं संगठन के विधवा-वधु का परिचय दिया।

इन संगठनों में श्री कोल्हापुर श्रीसागर ने इंडन पूर्ण संसाधन संस्थान के बारे में जानकारी दी। उन्होंने मुख्य-श्री संवाद से लेकर जूनियरस एवं यूनियन के शुद्ध अवसर से आने के विषय में विचार रूप में बताया। श्री समस्या रा. राम ने जूनियरस प्रमुख पालक के बारे में जानकारी दी कि जूनियरस शुद्ध अवसर से आने में किस-किस चरणों में गुजरता है। श्री अमृत प्रकाश ने इंडन संवाद संविधान संस्थान की जानकारी दी कि किस तरह मिलने आकांक्षेप इंडन का निमन्न किया जाता है। साथ ही उन्होंने मिलते आकांक्षेप इंडन की उपस्थिति के बारे में भी बताया। श्री नंदकुमार ल. साराय ने अपरिष्ठ प्रवविध सुविधाएं, संवादों की जानकारी दी और बताया कि कोमर्चिन्त्र क्षेत्र में अपरिष्ठ प्रवर्धन किल्ला महायुगपत है। श्री ज्ञानेंद्र रा. वादव ने स्वास्थ्य भौतिकी के विषय में बताया कि न्यायिकी क्षेत्रों में कम करवाहें कर्मचारियों के स्वास्थ्य के बारे में क्या क्या सावधानियों ली जाती हैं। साथ ही वातावरण एवं आम प्रेम के क्षेत्र की माननीयता कैसे करता है, यह भी बताया।

इन दो विश्वसंगीतों में विभिन्न संस्थानों एवं समाचार नेटवर्क ने दिनांक 13/10/2003 को श्रीमती 40 प्राधिकरण कर्मचारियों ने और 20/10/2003 को करीब 50 हेल्पर एवं ट्रेडमैन ने भाग लिया।

4.0 स्वास्थ्य विषय पर बातचीत

दिनांक 17/10/2003 को भाषाविद्या संविधान विषयों पर भी बातचीत रची गई। इसमें डा. धर्मशाला राम जीन ने इट्टे में
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.
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 session 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.

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.

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

• ड्र. श्रीकुमार बंगरी, हाल में ही नियुक्त भाय.प.अ. केंद्र के निदेशक, विभिन्न पुरस्कारों एवं सम्मानों के प्राप्तकर्ता हैं जिनमें इंजीनियरिंग साइंस भवनागर पुरस्कार (1989), जी.डी. बिरला गोल्ड मेडल ऑफ द इंडियन इन्स्टिट्यूट ऑफ मेटल्ज (1997), आई प्लस एस ए प्राइज़ फॉर मेटालरियल साइंस (2001), एवं द एकटा मेटालरिका आउटस्टेंडिंग पेपर अवार्ड (1984) भी शामिल हैं। हाल ही में इन्होंने मेटालरियल साइंस के क्षेत्र में उत्कृष्ट योगदान
Dr Srikumar Banerjee, the newly appointed Director of BARC, is the recipient of several awards and honours which include the Shanti Swarup 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.

- 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.

- 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.

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.
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 world’s 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.
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<th>Country</th>
<th>Reactors in operation May 2004</th>
<th>Reactors under construction May 2004</th>
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