IGC Newsletter

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From the Director's Desk

New Year Message

It gives me great pleasure to wish you and your family the very best in the year 2009. Inspiration, rigor and vigor are the hallmarks to enable us delivering excellence in all our endeavors; be it science, mission mode research, technology development or societal commitment.

As a Centre, we have done well in the last one year with respect to various milestones and achievements, as seen from the perspective of our peers and planners. Our performance in meeting the commitments, such as high performance of FBTR operation, necessary inputs for PFBR construction, fuel cycle activities, engineering and basic research, infrastructure development, human resource development, even budget management etc, has been good. However, the issue to be introspected is whether we have performed well based on our full potential. I feel that we can achieve at least 30% more in our productivity, efficiency and quality in the year 2009. Perhaps, you may have a different figure for the improvement. But, it is only by aiming high and improving our past performance, we can achieve higher goals and excellence in our endeavors. The roadmap and the milestones in our areas of pursuit are well defined and accepted by different groups and the management. Successful commissioning and operation of PFBR, design of next four fast breeder reactors with enhanced safety & economics, launching of the construction of fast reactor fuel cycle facility, development of metallic fuel cycle, building robustness in our engineering development and reprocessing programmes, would be the major areas to be pursued. Science and Engineering research for breakthroughs is our firm belief to become the leader in fast reactor science & technology. Towards these goals, apart from using our in-house quality manpower, we are also synergizing with BARC, various DAE units, national laboratories and eminent academic institutes to bring in fresh ideas as well as cross-fertilization of ideas and concepts. Young training school officers, research scholars and students of academic institutes working in our

Centre have brought in noticeable enthusiasm and youthfulness and enhanced our fun and capacity to achieve successes at a faster pace. We have also satisfactorily mentored and nurtured these young persons, so as to build a stronger and vibrant India for tomorrow.

We can feel proud seeing greener and more beautiful IGCAR and wonderful townships, thanks to sustained and sincere efforts put in by our colleagues. Well managed schools with good quality of education and the hospital with better medical facilities are the important attributes and attractions of our township. This has been possible due to dedicated efforts of the responsible people and further, constant improvements due to close interactions and constructive criticism from various members. I have a special regard for all the Associations in IGCAR and GSO, who have been partners in building and establishing a coherent synergy with the management to move on the path of excellence in all our endeavors. This relation is based on mutual trust, maturity and accountability.

I would like to share my feelings on the occasion of the New Year 2009. In my childhood and young days, when I interacted with successful persons, I used to think that they were lucky and hence, successful. But today, after years of learning, toil and maturity, it is clear to me that successful people are those who have a clear vision, self-confidence, hard work, perseverance, passion and commitment to individual goals as well as the goals of the organization.

We could reap the Green Revolution, we could harness the information technology. We could build reactors to split the atom, we could make rockets to reach the moon. If we could all these, we can also achieve many more wonders. If you think we can, we can.

May you achieve much more in the year 2009 with all your hard work and dedication.

With my best wishes and warm regards,

(Baldev Raj)
Director, IGCAR & GSO

"…. The relative role of indigenous science & technology and foreign collaboration can be highlighted through an analogy. Indigenous science & technology plays the part of an engine in an aircraft, while foreign collaboration can play the part of a booster. A booster in the form of foreign collaboration can give a plane an assisted take-off, but it will be incapable of independent flight unless it is powered by engines of its own. If Indian industry is to take-off and be capable of independent flight, it must be powered by science & technology based in the country…"

- Homi Jehangir Bhabha

May every moment of the New Year
be filled with Joy, Happiness & Prosperity
And may you fulfill all your dreams

Baldev Raj
Director, IGCAR & GSO

Determination of Diverse Safety Rod Position during SCRAM using Acoustic and Ultrasonic Methods

Introduction

Development of acoustic method for the drop time measurement of Diverse Safety Rods (DSRs) in Prototype Fast Breeder Reactor is in progress. This technique is based on the methodology of detecting impact noises produced during the entry of Diverse Safety Rod into the dashpot. Tests were carried out in Diverse Safety Rod Drive Mechanism Test Facility using ultrasonic sensors, to determine the exact position of Diverse Safety Rod inside the Subassembly with time after a SCRAM and to validate the acoustic method.

The experiment was carried out during the testing of Diverse Safety Rod in sodium at 473K using the Accelerometer and Ultrasonic sensor. Accelerometer was mounted on Diverse Safety Rod Drive Mechanism and ultrasonic sensor was fixed on the dashpot bottom end as shown in Figure 1. The transducer is capable of transmitting ultrasonic signals around 4MHz frequency. The transmitted signal would be reflected back from the Diverse Safety Rod bottom end and would be received by the same transducer. The current height/distance of the Diverse Safety Rod from the bottom end can be calculated using the time delay between the transmitted pulse, received echo and the velocity of ultrasonic waves in sodium (2,472m/s).

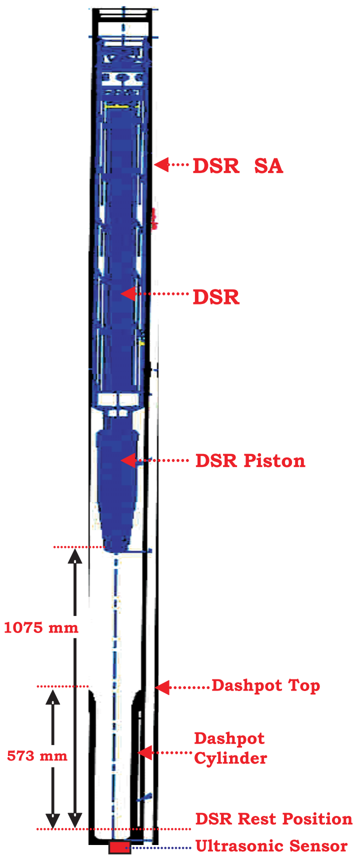


Figure 1 : Diverse Safety Rods Subassembly & Dashpot

Experimental Procedure & Results

Prior to the continuous position monitoring of the Diverse Safety Rod, discrete position determination of the Diverse Safety Rod was carried out. During this test, Diverse Safety Rod was kept at different heights inside the subassembly and the transmitted pulse and reflected echoes from ultrasonic sensors were recorded and the position of the Diverse Safety Rod was calculated. Figure 2 shows the time plot recorded when the Diverse Safety Rod was kept at a height of 495mm from its rest position. The actual elevation of Diverse Safety Rod as calculated from the Ultrasonic method was found to be 492mm.

After the completion of discrete position determination, validation of acoustic method using ultrasonic technique was carried out. The time signals obtained in the acoustic sensors are complex in nature, characterized by impacts at various locations during its entry into the dashpot. To confirm the acoustic signal pattern and to compare with ultrasonic technique, Diverse Safety Rod was dropped from a height of 1065mm. During this experiment the ultrasonic gate position was set at the bottom most point of the dashpot. The Electromagnet de-energizing signal, accelerometer signal and the gate output signal were monitored continuously in a digital oscilloscope. Figure 3 shows the typical time plot and the total fall time as recorded from the ultrasonic signal was 774mS whereas from the acoustic sensor was 781mS. The difference in time may be attributed to the fact that the

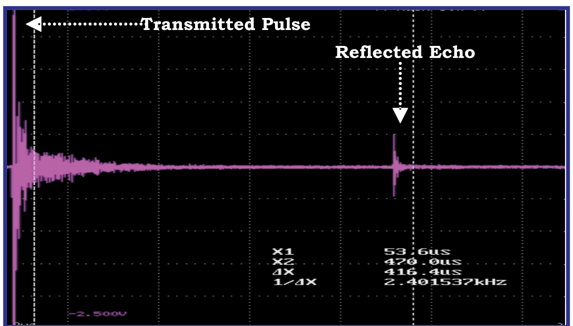


Figure 2 : Transmitted pulse & echo [DSR at 495mm]

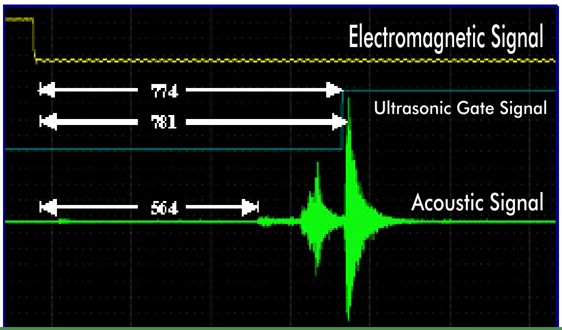


Figure 3: Time signal [DSR at 1065mm]

acoustic sensor picks up the impact signal at an elevation of around 11m from the impact location and a slight delay can occur due to the propagation of the shock waves through the sodium and the structural material. Moreover the limitation in setting the minimum possible height of the gate can also add to this difference.

In order to determine the position of the Diverse Safety Rod over its entire travel inside the subassembly after the SCRAM continuous position determination of Diverse Safety Rod was carried out. During this experiment Diverse Safety Rod was dropped from a height of 1065mm and the transmitted ultrasonic pulses and its echoes were continuously measured along with the signals from electromagnet and the accelerometer. The position of the Diverse Safety Rod was calculated from the recorded signal and was plotted against time as shown in Figure 4.

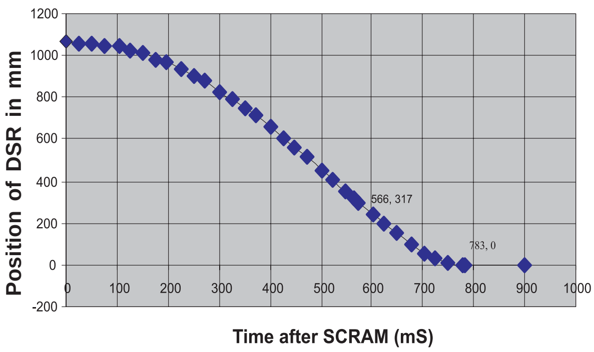


Figure 4: DSR Position Vs Time Graph

Analysis & Conclusion

Once the Diverse Safety Rod is released from the electromagnet the velocity of Diverse Safety Rod increases slowly (as expected) and reaches the maximum velocity, during travel as seen in Figure 4. The velocity starts decreasing as it enters the dashpot and finally it is brought to rest by the dashpot action. Figure 5 represents the Diverse Safety Rod piston profile highlighting the variation in the dimension which causes the impacts and Figure 6 represents the dashpot inner profile and Figure 7 shows the final location of Diverse Safety Rod inside the dashpot.

The total dashpot height is 573 mm and from the Diverse Safety Rod dashpot inner profile (Figure 6), it can be seen that at a location 60 mm below the dashpot entry only Diverse Safety Rod can hit while entering inside. Therefore the effective location of first hitting will be around 513 mm from the final resting position of Diverse Safety Rod. From Figure 5, it is clear that when the first hit occurs Diverse Safety Rod will already be around 200 mm inside the dashpot. Calculating from these inputs we can find that when the acoustic sensors detects the first impact, the bottom end of the Diverse Safety Rod will be at a height of around 313 mm from the bottom rest position of Diverse Safety Rod. The value corresponding to the first hit as obtained from Diverse Safety Rod position versus time chart (Figure 4) is found to be 317mm. These values are found to be in good agreement with each other. The methodology followed for identifying the free fall time and total drop time by acoustic detection technique is found to be accurate. Hence, this method can be adopted for determining the exact position of Diverse Safety Rod inside the Subassembly.

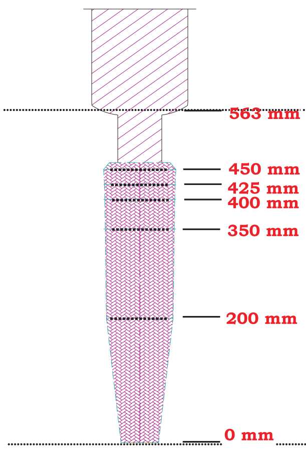


Figure 5 : DSR Piston Profile

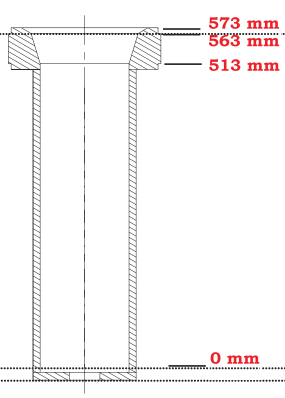


Figure 6 : DSR Dashpot

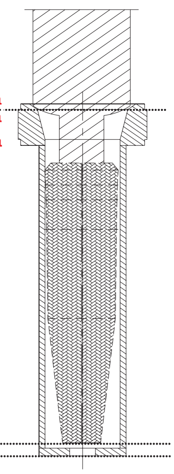


Figure 7 : DSR Final position

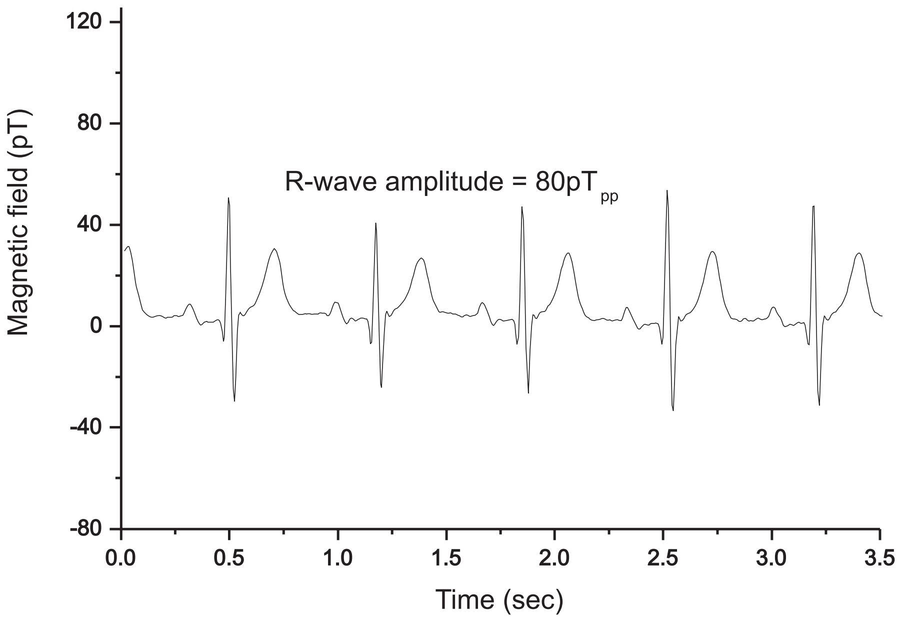
(Reported by V. Prakash, Separation Technology & Thermal Hydraulics Division, FRTG)

Establishment of Facilities for Superconducting Quantum Interference Device (SQUID) based Magnetoencephalography

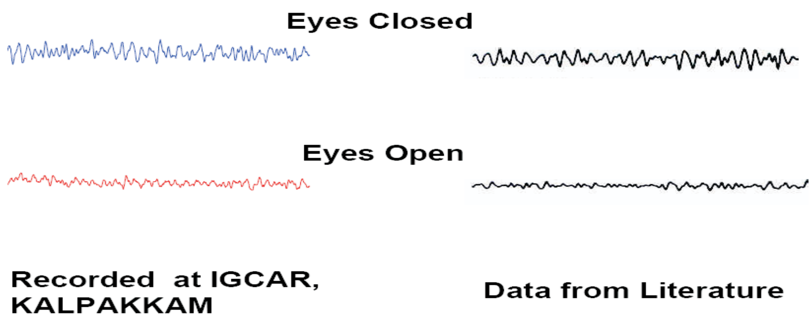
Magnetoencephalography involves the non-invasive measurement and characterization of magnetic fields associated with the physiological activities of human brain and represents one of the most challenging application of Superconducting Quantum Interference Device (SQUID) sensors. These magnetic fields, typically ~1picoTesla(pT) or less, are indeed so weak that they are virtually not measureable by any other sensor technology. Based on the earlier success in utilization of SQUID sensors in the development of systems such as SQUID magnetometer and SQUID based system for Non-Destructive Evaluation (NDE) facilities have been set up at our Centre for measurement of extremely weak magnetic fields associated with physiological activities of human heart and human brain. A survey of the ambient magnetic noise was conducted to pick-up a magnetically quiet site with a measured magnetic noise of 100pT /√Hz in the white noise regime and with a peaking at 6 nanoTesla(nT) at 50Hz. A special building using Grade 316 stainless steel rods to reinforce concrete was constructed to minimize disturbances due to ambient magnetic noise; experiments showed that the influence of external magnetic disturbances was eight times lower in this stainless steel reinforced building when compared to a conventional building using ferromagnetic mild steel reinforcement. A special one meter deep concrete block weighing about fifty tonnes and reinforced with stainless steel served as a foundation to erect the Magnetically Shielded Room with a view to reduce vibration levels to below 10^{-4} m/sec^2. This is the first Magnetically Shielded Room in India and was installed and commissioned at IGCAR in December 2006. The Magnetically Shielded Room has two layers of μ-metal (2mm and 3mm thick) and two layers of aluminum (8mm and 4mm thick) and provides a measured shielding factor of 70dB at one Hz, which improves to 100dB at 100Hz.The Magnetically Shielded Room is equipped with several penetrations for stimulus presentation, helium gas recovery etc. and is connected to a Radio Frequency Shielded Room by four 100mm diameter shielded waveguides to route the SQUID cables. A Fibre Reinforced Plastic liquid helium cryostat housing the SQUID sensors is located inside the Magnetically Shielded Room while the measurement electronics is located inside the Radio Frequency Shielded Room. The signal to be measured is coupled to the SQUID sensor via a first order superconducting gradiometer having a loop diameter of 15mm and a baseline of 50mm. The SQUID output voltage was digitized with a 16 bit resolution and was recorded at a sampling rate of 300Hz. The system noise floor was measured to be 20-30 fT /√Hz, which is adequate for measurement of biomagnetic fields.

For the measurement of heart signal, the subject lay supine with his chest under the liquid helium cryostat and the component of magnetic field normal to the chest surface was measured. The SQUID output revealed the 'P' wave related to depolarization of the atria, the QRS peak related to the depolarization of the ventricles and the 'T' wave related to the repolarization of the ventricles. The signal strength of the 'R' peak was over 50 pT and could be measured clearly with a high signal-to-noise ratio. Measurements were repeated at different positions on the chest to map the spatial distribution of the cardiac magnetic

Magnetically Shielded Room Coupled to Radio Frequency Shielded Room via Shielded Waveguides Shielding Factor 70 dB @ 1Hz improving to 100dB @ 100Hz



MCG signal of a 47 year old male



MEG Signals from the Occipital Lobe

field. The cardiac signal could also be measured on the posterior back surface of the subject although with a slightly reduced intensity because of a higher stand-off distance.

For the measurement of Magnetoencephalography signal, the sensor was positioned above the scalp at the desired position. For the measurement of the alpha rhythm, the sensor was positioned on the occipital lobe of the brain and the SQUID output was measured with eyes open and with eyes closed. Signal in the eyes closed condition was observed to be larger in amplitude and revealed a peak at 9 Hz in the frequency spectrum as expected. For the measurement of the signal corresponding to the eyeblink, the sensor was positioned just above the eyebrow line and signal amplitude of about 2pT was observed at each eyeblink. Studies on the measurement of evoked response to visual / auditory / tactile stimuli and to other neuro-cognitive tasks are currently underway. Since these responses are extremely weak (under 200 femto Tesla), and are masked by the α- rhythm of the brain having an amplitude of 2 pT, a large number of responses have to be measured by presenting identical stimuli in quick succession and averaging the recorded responses using the stimulus presentation instant as trigger. In this way, the response which is phase-locked to the presentation of the stimulus stands out while the other components of brain activity which are uncorrelated to the presentation of the stimulus get averaged to zero.

There are a number of advantages in the measurement of magnetic activity (Magnetocardiography/ Magnetoencephalography) as opposed to the more conventional measurement of electric activity (Electrocardiography/Electroencephalography). Electric activity measured on the skin by attaching leads is affected by the conductivity distribution of the tissues between the source and the measurement locations (which is often inhomogeneous and anisotropic with bones presenting very poor electrical conductivity) leading to distortions in the measured data. This problem is of much less concern in magnetic measurements since most tissues are weakly diamagnetic and do not distort the measured magnetic field distribution. The magnetic measurement is contact-less and avoids the problem of skin potentials contaminating the data. Measurement of magnetic fields associated with a given physiological activity may also be expected to give complementary information not contained in the electrical measurements.

Based on the success in measuring bio-magnetic fields using SQUID sensors, plans are underway to build a multi-channel Magnetoencephalography system. A 19-channel system with a flat bottom cryostat is under design, which will be upgraded in the coming years to a 64-channel system with a concave bottom cryostat. Efforts are underway to develop a multi-channel data acquisition system with a high sampling rate upto 20kHz. Necessary signal processing techniques and computational algorithms are also being developed. These developments will help to establish Magnetoencephalography technique in India as a reliable technique for probing the dynamics of human brain with a millisecond temporal resolution.

(Reported by M.P. Janawadkar, Materials Science Division, MMG)

Reconditioning of Boiler Feed Pump Shaft for Madras Atomic Power Station

Central Workshop Division was entrusted the job of salvaging of shafts for boiler feed pump of Madras Atomic Power Station. During the periodic maintenance, it was observed that the pump noise and vibration level were beyond limits. The pump was dismantled, the dimensions were measured and analyzed. It is found that the shaft was 0.2 mm under size at impeller seating area. It was decided to recondition the shaft by metal deposition by welding. The shaft was subjected to dye penetrant and ultrasonic examination to ensure that it is free from defects.

Central Workshop Division in collaboration with Materials Technology Division, MMG undertook the job. Considering the material composition, less heat input and elimination of post weld heat treatment, Magna 303 universal maintenance electrode was selected for weld overlay on EN 56 shaft material using Shield Metal Arc Welding (SMAW) process.

Shaft mounted on the weld set-up

Reconditioned shaft after welding

Precautions were taken to minimize distortion during welding. A weld set up was designed with variable welding speed arrangement and used. The shaft was mounted on the two roller supports on the set-up and leveled as shown in the Photograph. This arrangement was designed to measure and maintain straightness on line when the welding is in progress. Lower heat input, balancing and sequential welding techniques were adopted to minimize the distortion.

Liquid penetrant examination of the weldment and straightness measurement were carried out and found to be satisfactory. The shaft was machined in the lathe machine using steady rest and achieved the dimensions within tolerance of ± 0.2mm. The key way on the shaft was machined in the milling machine.

The re-conditioned shaft was subjected to final dimensional, ultrasonic examination and found to be satisfactory.

(Reported by A.S.L.K. Rao
Central Workshop Division, ESG)

Young Officer's FORUM

Shri T. Karthikeyan obtained his B.Tech degree in Metallurgical Engineering from the Indian Institute of Technology, Madras in 1997 and M.S degree in Materials Engineering from University of Houston, U.S.A. He is from KSKRA-2002 batch and joined IGCAR as Scientific Officer (SO/D) in July 2004.

Grain Boundary Engineering – A Concept to Overcome Embrittlement Problem in Ferritic Steels

The austenitic stainless steels that are used as clad tubes and wrapper in fast breeder reactors pose a limit in achieving high fuel burn-up, due to radiation induced dimensional changes above 100 displacements per atom(dpa). Ferritic steels, owing to their excellent void swelling resistance against irradiation (up to 200dpa), and good high temperature mechanical properties, are being considered as a wrapper material in fuel subassembly of oxide fueled fast reactors and for clad and wrapper in metal fueled fast reactors in the future. However, ferritic steels exhibit Ductile-to-Brittle Transition (DBTT) phenomena at low temperature and temper/irradiation embrittlement can cause increase in DBTT and/or lowering of upper shelf fracture energy, on long-term exposure to radiation and high temperature (673-873 K) environment of reactor core. Assessment and control of embrittlement problem, so as to retain adequate ductility/toughness over all handling temperatures after target fuel burn-up, is thus essential for ensuring the successful use of ferritic steels as fast reactor core component material.

Temper embrittlement in steels is generally associated with segregation of impurities (such as sulphur, phosphorus, tin and antimony), and precipitation of brittle phases at grain boundaries, and a brittle type of fracture along prior-austenite grain boundaries. The susceptibility to embrittlement is influenced by the service conditions, the composition of the alloy, impurity levels and the nature of grain boundaries. Low angle and Coincident Site Lattice(CSL) grain boundaries have low surface energy and are more resistant against segregation, precipitation phenomena and less susceptible to intergranular failure, compared to 'random' grain boundaries. The 'Grain Boundary Engineering' approach aims at increasing the fraction of low energy/'special' boundaries in 9Cr-1Mo ferritic steel by suitable Thermo Mechanical Treatment (TMT), and thereby mitigating the embrittlement problem.

The 9Cr-1Mo ferritic steel is used in normalized and tempered (N&T) condition, which results in a tempered martensitic microstructure consisting of carbide precipitates (such as $M_{23}C_6$, MX or M_2X, where M represents metal, X represents carbon/nitrogen) at lath/packet boundaries of ferrite phase and prior-austenite grain boundaries. Figure 1 shows the schematic of the Scanning Electron Microscopy-Electron Back Scattered Diffraction(SEM-EBSD) orientation imaging microscopy, used to characterize the orientation of *bcc* crystal in ferrite grains, and in evaluating the grain boundary nature. The 9Cr-1Mo steel in the as-Normalized and Tempered condition exhibited 4% low angle and 35% Coincident Site Lattice boundaries.

In an assemblage of grains consisting of both random and low energy boundaries, the propagation of a crack requires connectivity of the random boundaries or in other words, a network. A critical minimum fraction of low energy

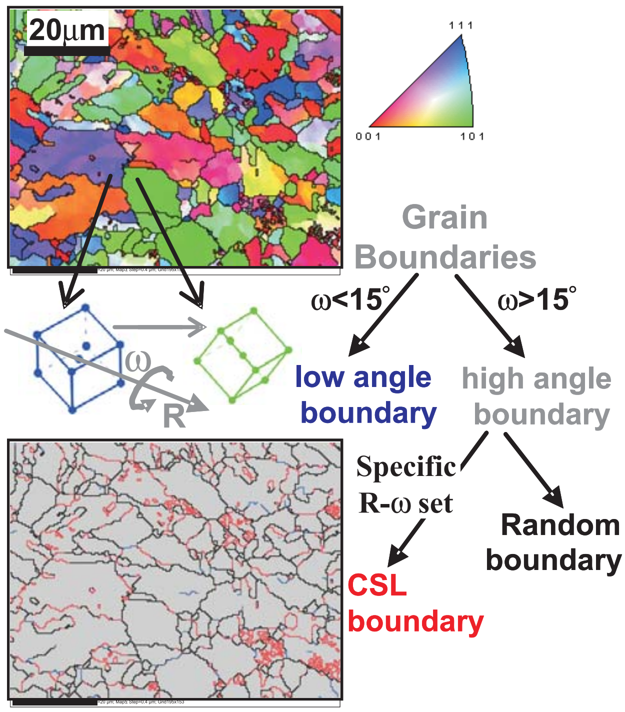


Figure 1 : Illustration of crystal orientation map and grain boundary map for a 9Cr-1Mo steel in normalized and tempered condition

boundaries would be necessary to break the network of 'random' boundaries that are susceptible to intergranular cracking. This fraction was assessed by modeling the intergranular crack connectivity in a simulated Poisson-Voronoi grain structure (Figure 2(a)). Poisson-Voronoi grain model is a geometrical model obtained by uniform isotropic growth of randomly distributed grain nuclei in space, and it results in polyhedral grain structure similar to real polycrystalline materials. It results in a self-similar structure, which is independent of the grain size. Monte Carlo technique was used to distribute the 'f' fraction of crack resistant boundaries and the remaining crack susceptible boundaries, and the statistical probability of intergranular crack connectivity (by 1-D and 2-D network) from one face of the cube to the opposite was evaluated. A percolating cluster of 1-D network of susceptible grain boundaries is illustrated in Figure 2(b). A sharp transition in percolation probability from 1 to 0, is observed at 80% and 20% - 'f' values, for 1-D and 2-D networks respectively (Figure 2(c)). Material failure by intergranular crack propagation occurs over a 2D surface, and hence the percolation threshold based on 1-D crack network is a conservative estimate. On the other hand, 2-D network modeling is an over estimate, since a complete material breakage is assumed to be prevented by the last few ligaments of crack resistant boundaries, which is not actually feasible.

Modeling studies provided a guideline for the amount of crack resistant/low energy boundaries required to prevent intergranular fracture in materials. With this basis, several Thermomechanical Treatments consisting of deformation by different modes and at different temperatures were carried out on modified 9Cr-1Mo steel with the objective of increasing the fraction of Coincident Site Lattice boundaries. The grain boundaries were identified based on minimum misorientation angle of 10° and the Coincident Site Lattice boundaries were distinguished using Brandon's criteria. A final Normalized and Tempered heat treatment for all cases was employed to obtain the desired tempered martensitic microstructure and hardness. Table 1 lists the % Coincident Site Lattice boundaries for the various treatments. Compared to Normalized and Tempered treatment, the hot forged + Normalized and Tempered treatment alone showed an improvement in % Coincident Site Lattice to 34.1%, whose grain orientation map is shown in Figure 3.

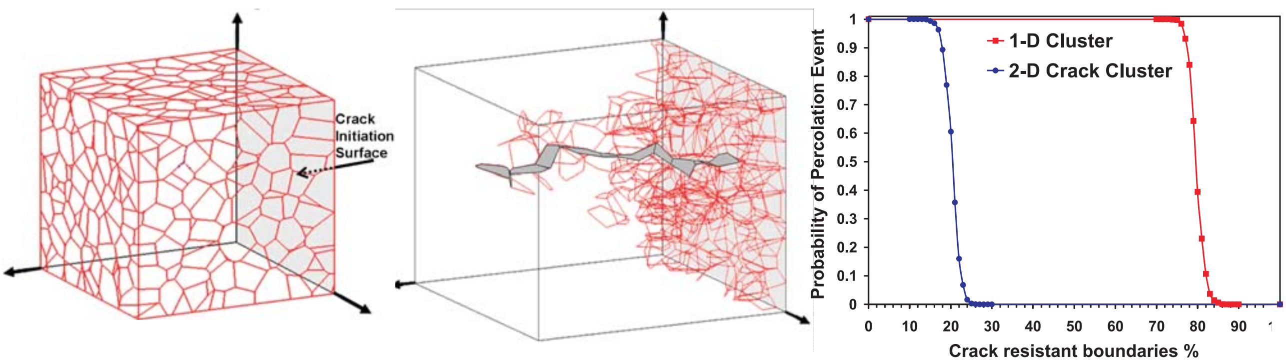
Table 1

Amount of Coincident Site Lattice (CSL) boundaries obtained in Modified 9Cr-1Mo steel by thermomechanical treatment

Thermomechanical Treatment	% CSL
As-Normalised and Tempered	33
80% Cryo rolled, Normalized and Tempered	22
80% Cold rolled, Normalized and Tempered	22
20% Cold forged, Normalized and Tempered	27
40% Hot forged, Normalized and Tempered	34

Another set of studies were performed where the 9Cr-1Mo steel was subjected to a controlled deformation by unidirectional rolling at room temperature. The effect of % deformation (5, 10, 15 and 20%) followed by two types of heat treatments namely Re-crystallization and Normalized and Tempered treatment on fraction of low energy boundaries has been examined. The grain boundary characteristics and the hardness property variation due to different extent of deformation are given in Table 2. The Coincident Site Lattice % for 'Cold rolled + Normalized and Tempered' treatment was significantly reduced for small reductions, but showed an optimum increase to 38.9% for 15% deformation. The Coincident Site Lattice % for 'Cold rolled + Re-crystallization' treatment increased with increasing percentage of deformation with 20% deformation exhibiting 42.9% Coincident Site Lattice and 51.7% random boundaries. The grain boundary maps corresponding to two Thermomechanical Treatments with enhanced Coincident Site Lattice are shown in Figure 4.

It is known that reduction of grain size gives improvement in fracture properties and decrease in Ductile-to-Brittle Transition in steels. The role of grain size in susceptibility to grain boundary fracture and impact toughness properties were studied by modeling and experimental methods. Propagation of intergranular crack along susceptible



(a) (b) (c)

Figure 2 : Intergranular crack connectivity in a simulated grain structure (a) Schematic of equiaxed grain structure simulated by Poisson-Voronoi model (b) Illustration of 1-D percolating cluster of crack susceptible boundaries for f=85% (c) Probability of 1-D and 2-D percolation event as a function of amount of crack resistant boundaries

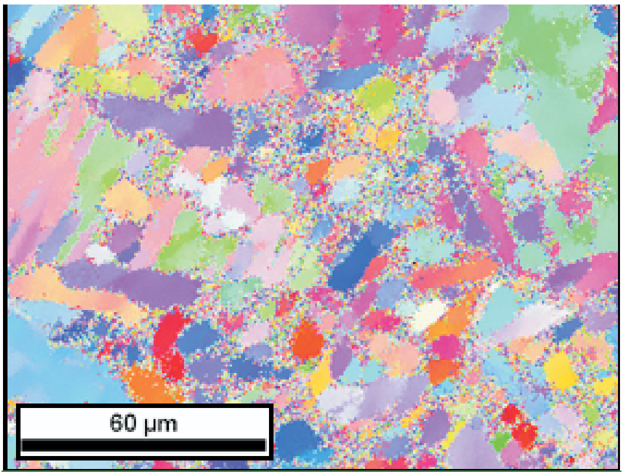


Figure. 3 : Crystal Orientation Map of 9Cr-1Mo steel after hot forging + Normalized and Tempered treatment

boundaries in a simulated hexagonal grain structure of different average grain sizes was studied, for various fractions of susceptible grain boundaries. Monte Carlo technique was used to distribute the crack susceptible boundaries randomly in the structure. Figure 5(a) illustrates the hexagonal grain lattice, a specific instance of distribution of crack susceptible & crack resistant boundaries, and crack propagation along susceptible boundaries from top. The number of grain layers traversed by the crack is multiplied by the grain size to get the actual crack length. Brittle failure of materials is primarily dictated by crack initiation stages, and for a given material and applied load, there exists a specific critical crack length, beyond which the material is bound to fracture. The statistical probability of interconnected weak boundaries exceeding this 'critical crack length' is an index indicating the susceptibility to intergranular crack initiation in materials. This was evaluated (based on thousand Monte Carlo cycles in a 90x90 hexagon matrix)

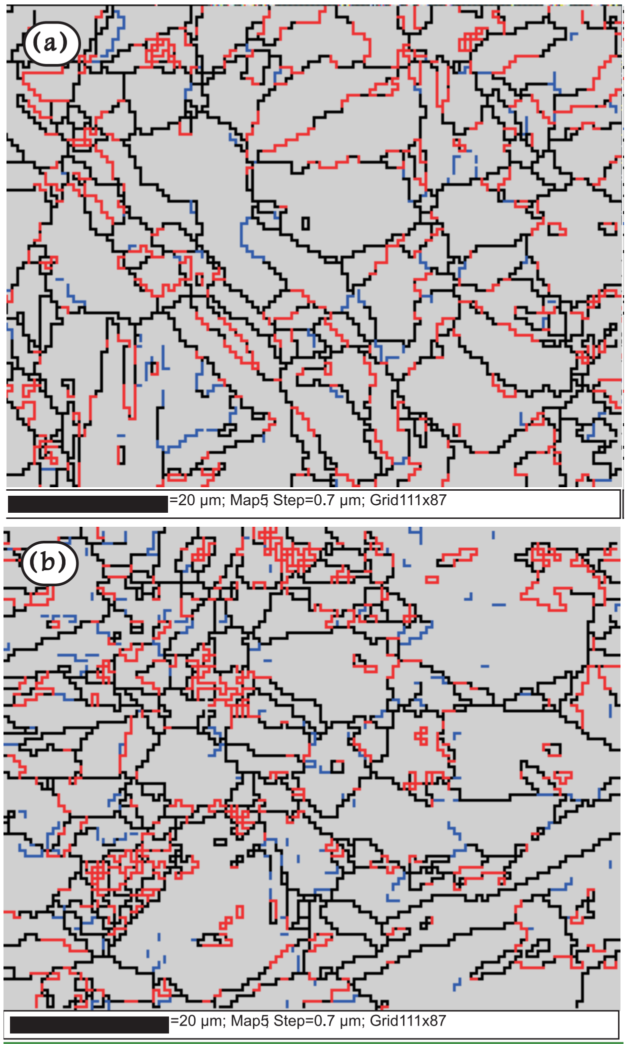


Figure 4 : Grain boundary map (red (a), blue-low angle, black-random) of 9Cr-1Mo steel for
(a) 15% Cold work+Normalized and Tempered
(b) 20% Cold work+Recrystallisation treatment

Table 2

Grain Boundary Characteristics after thermomechanical treatment of 9Cr-1Mo steel

Thermomechanical Treatment		Low Angle %	Coincident site Lattice %	Random boundary %	Hardness (VHN)
Deformation %	Heat treatment				
Reference (Normalized and Tempered)		4	35	61	230
5	Normalized and Tempered	8	19	73	253
10		6	25	69	246
15		5	39	56	249
20		6	27	67	252
5	Recrystallisation	7	26	67	241
10		4	39	57	244
15		5	40	56	250
20		5	43	52	247

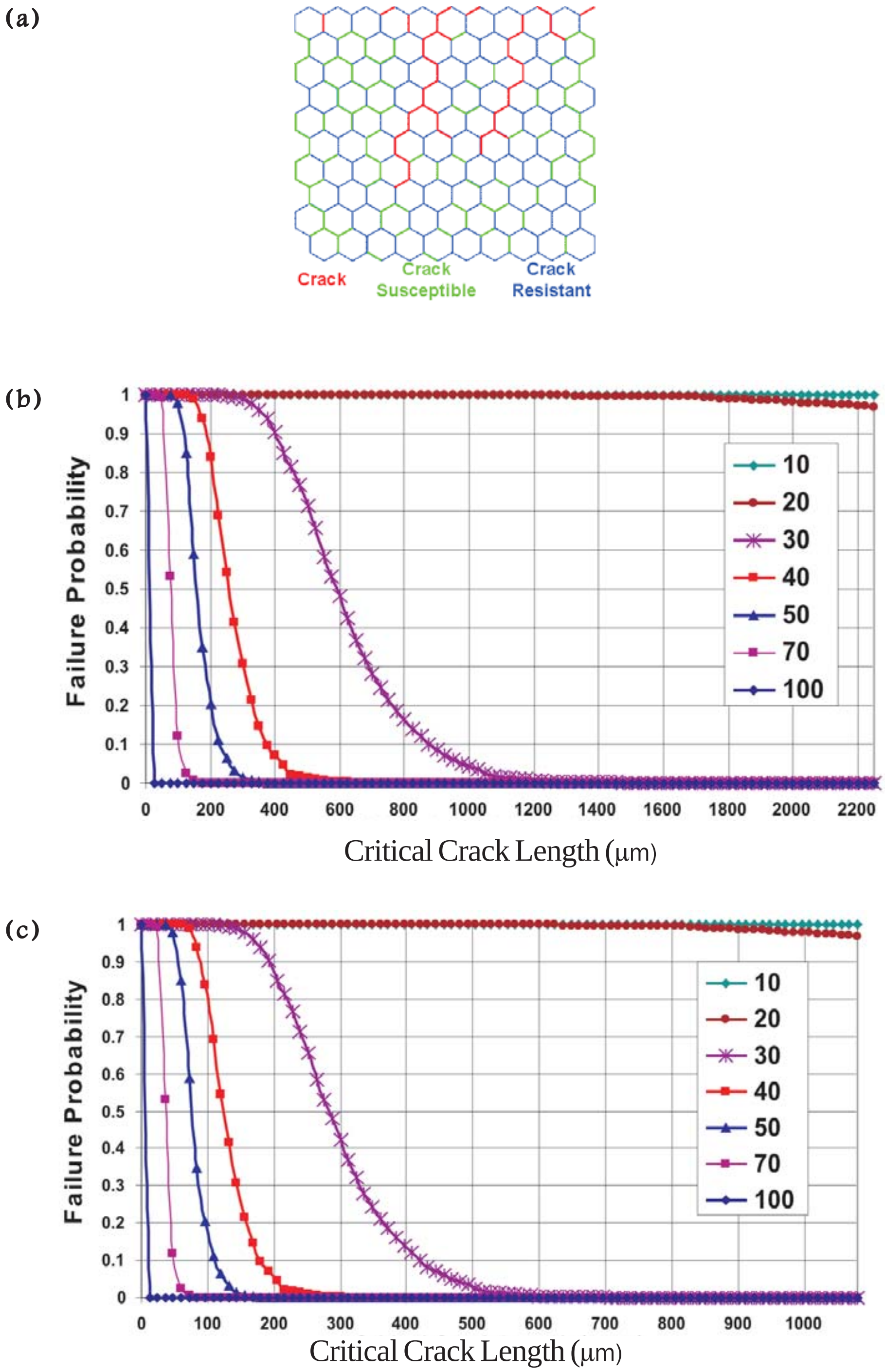


Figure 5 : (a) Simulation of intergranular crack along susceptible boundaries in a hexagonal grain lattice, and probability of failure as a function of critical crack length for two different grain sizes, of (b) 25μm and (c) 12μm

for two types of average grain sizes, 25μm and 12μm, and the result is given in Figure 5(b) and 5(c) respectively. Reduction in grain size leads to lower failure probability for a given fraction of susceptible boundaries. For example, if the crack susceptible grain boundaries are 50%, and if the critical crack length for failure is 100μm, then the probability of intergranular failure is seen to reduce from 95% in a coarse grained lattice (25μm) to 20% in a fine grained lattice (12μm).

A two-stage normalization treatment was designed, which reduced the prior-austenite grain size from 25μm to 12μm. Charpy tests were carried out to evaluate the impact toughness at various temperatures for the conventional Normalized and Tempered condition and the steel with grain size refinement. Ductile-to-Brittle Transition decreased by 15K with reduction in grain size improved the room temperature impact energy. Thus, control of grain size and grain boundary nature can effectively be used to minimize the embrittlement problem in ferritic steels.

(Reported by T. Karthikeyan, Physical Metallurgy Division, MMG).
(He is the recipient of 'INAE Young Engineer Award 2008' for this work)

Young Researcher's FORUM

New Ion Exchange Resins for the Recovery of Actinides and Precious Metal

Shri R. Kumaresan obtained his M.Sc., in Chemistry from Madurai Kamaraj University in 2002. He has submitted his Ph.D., to the University of Madras in May 2008. His area of research is on Synthesis and evaluation of new ion exchange resins for actinides and precious metal recovery. He is presently working on Minor actinides recovery project at Fuel Chemistry Division, IGCAR.

Introduction

Ion exchange is a well-established technique and has been widely applied to various stages of the nuclear fuel cycle such as, uranium ore processing, removal of contaminants from the primary coolant circuits, condensates and fuel storage pond water, recovery of plutonium and other transuranics, radioisotope separations etc. In the last few decades, the application of ion exchange processes in nuclear industry has increased significantly. Mostly, ion exchange processes using organic ion exchangers have been established for the metal ions separation. Much of the work with respect to the advances in the process of manufacturing ion exchange resins was partly driven by the need to separate radionuclides. A number of studies have been reported on the separation of radionuclides addressed two major requirements (i) resins with good radiation stability and (ii) resins offering faster kinetics of uptake of metal ions.

To address the above issues and also to develop totally indigenous alternatives, we have undertaken the development of poly[styrene-divinylbenzene](PS-DVB) based indigenous anion-exchange resins viz., Tulsion A-PSL 4, Tulsion A-PSL 6, and Tulsion ABF-22, for plutonium processing, in close collaboration with M/s.Thermax Ltd., Pune. All these resins were synthesized by suitable choice of, the degree of cross-linkage, the initiator for polymerization and its quantity, reaction temperature, amination solvent and amine addition parameters, with an aim to achieve produce with improved thermal and radiation stability as well resistance to osmotic shocks. We also synthesized radiation stable ion exchange resins namely, poly (vinylpyridine-divinylbenzene) (PVP) with various degrees of cross-linkage and evaluated them for the recovery of plutonium and palladium.

Three different cross-linked gel-type resins namely 4, 8, and 12% (mole percent) and two macroporous resins in the presence of solvating and non-solvating diluents were prepared using suspension polymerization technique. Figure 1 gives the schematic of the synthesis of weak-base PVP resin and subsequent methylation to prepare the strong base PVP-Me resin. The resins were characterized by FTIR, TG-DTA, elemental analysis, measurement of bulk density and specific surface area. The morphology, sphericity, and the porosities were studied using scanning electron microscope. The SEM pictures of the gel-type PVP resins are shown in Figure 2. It can be seen that the gel-type resin beads are spherical without any agglomeration (2a). The morphology of the macroporous resin are also shown indicating spherical shape (2b) and surface roughness in different magnifications (2b, 2c and 2d).

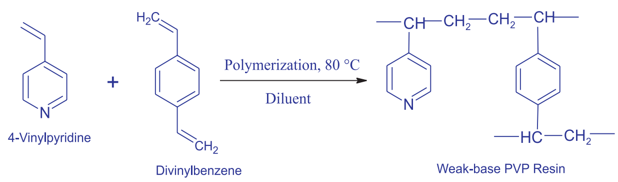


Figure 1 : Schemataic diagram for the synthesis of poly (4-vinylpyridine-co-divinylbenzene)

Recovery of plutonium using strong-base (PVP-Me) resins

Initially, three gel-type, strong-base PVP-Me resins were studied for the extraction of plutonium. The kinetics of sorption and elution of plutonium, uptake behaviour of plutonium, uranium, thorium, and americium, and radiation degradation studies were carried out in detail and the results were compared with those of the bench mark resin, Dowex 1X4. Figure 3 depicts the effect of cross-linkage of PVP-Me resin on plutonium sorption kinetics at

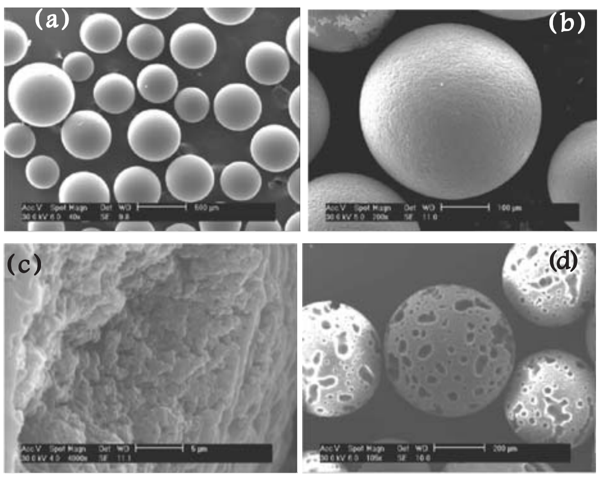


Figure 2 : SEM pictures of gel and macroporous PVP resins

8M nitric acid. The 4% PVP-Me resin exhibited faster plutonium uptake, but lower $D_{Pu(IV)}$ values compared to other cross-linked resins. The 12% PVP-Me resin exhibited poor kinetics, and did not attain equilibrium even after twenty four hours.

In general, PVP-Me resins showed very low $D_{Pu(IV)}$ values at lower acidities and better elution kinetics as compared to Dowex 1X4. Among the PVP-Me resins, 4% cross-linked resin exhibited best plutonium elution kinetics. Nevertheless, the high swelling behaviour in acidic media limited its practical applications. The results on radiation degradation studies brought out the high radiation stability of 8% PVP-Me resin, over conventional PS-DVB based anion-exchange resins. While the Dowex 1X4 and Tulsion PSL-4 and PSL-6 resins exhibited complete degradation at the total cumulative dose of 200 MRad, 8% PVP-Me resin retained its bead shape and showed lesser $D_{Pu(IV)}$ values. Studies were also carried out on a macroporous and an expanded gel PVP-Me resins, for the extraction of plutonium. The macroporous resin showed high $D_{Pu(IV)}$ values compared to expanded gel. The propylated version of the PVP resin, i.e. 4% PVP-Pr exhibited high $D_{Pu(IV)}$- values compared to 4% PVP-Me resin.

Studies on palladium recovery using Polyvinyl pyridine (PVP) resins

The recovery of platinum group metals from high level liquid waste will solve the problems during the vitrification process and will resolve the precious element scarcity in the near future. The use of polyvinylpyridine (PVP) resins becomes attractive due to the higher radiation stability as compared to the styrene-based resins. Hence, the recovery of palladium from HLLW was investigated using weak-base PVP resins. Three weak-base PVP resins with 4, 8 and 12% cross linkage, one strong base 4% cross linked PVP-Me resin and two macroporous resins with 20 and 25% cross linkage were synthesised and studied in detail for palladium recovery applications. Since the macroporous resins exhibited low $D_{Pd(II)}$, the studies focused more on the gel type resins.

Mechanism of palladium extraction

Table 1 shows the variation of $D_{Pd(II)}$ with nitric acid concentration. The 4% cross-linked PVP resin exhibits high $D_{Pd(II)}$ values compared to 8 and 12% cross-linked resins at all acidities. In the case of 8 and 12% cross-linked resins, $D_{Pd(II)}$ values increase with increase in the nitric acid concentration, reach a maximum at 4-6 M HNO_3 and tend to decrease. The anion exchange behaviour of palladium is observed for both 8 and 12% PVP resins. The following equations represent the sorption behaviour of palladium in PVP resins at higher nitric acid concentrations.

$$\overline{RN} + HNO_3 \Leftrightarrow \overline{RNH^+ . NO_3^-}$$

$$\overline{2RNH^+ NO_3^-} + [Pd(NO_3)_4]^{2-} \Leftrightarrow \overline{(RNH)_2[Pd(NO_3)_4]} + 2NO_3^-$$

$$\overline{RNH^+ NO_3^-} + [Pd(NO_3)_3(H_2O)]^- \Leftrightarrow \overline{RNH[Pd(NO_3)_3(H_2O)]} + NO_3^-$$

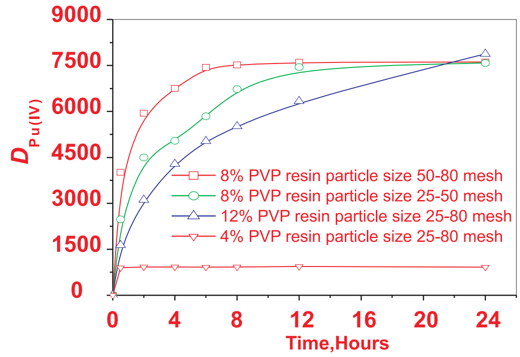


Figure 3 : Variation of D_{Pu}(IV) with equilibration time at 8 M nitric acid at 30°C

The strong–base 4% PVP-Me resin was also examined for palladium sorption in various nitric acid concentrations and the results are presented in Table 1. The 4% strong-base PVP-Me resin exhibits low $D_{Pd(II)}$ values at lower acidities, maximum $D_{Pd(II)}$ between 1 and 2 M, after which sorption steadily decreases with increase in nitric acid concentration.

In the case of weak base resin with 4% cross-link, $D_{Pd(II)}$ values steadily decrease with the increase in nitric acid concentration. This unique behaviour may be attributed to either hydrolysis followed by precipitation or coordination of palladium with pyridenium nitrogen atom at lower acidities. Figure 4 shows the SEM picture of 4% PVP resin loaded with palladium from 0.1 M HNO_3 solution, in which the hydrous palladium oxide precipitate over the resin surface can clearly be observed. FT-IR and XPS studies on palladium-loaded resins revealed the possible existence of coordination between palladium and nitrogen atom of the pyridine ring. However, the extent of coordination could not be ascertained and further studies will only provide exact mechanism. The column runs were performed with both 4 and 8% PVP resins, to study the loading and elution behaviour of palladium. The 4% PVP resin exhibited high palladium sorption capacity than 8% PVP resin. The maximum sorption was about 83% of the theoretical sorption capacity (4.5 meq/g) of divalent anion. Quantitative elution of palladium could be achieved using 0.5 M of acidic thiourea solution. Experiments performed with simulated HLLW solution indicated the possibility of palladium recovery with high decontamination factors.

Table 1

Batch extraction of Pd(II) in various nitric acid concentrations using weak-base PVP resins at 25°C

$[HNO_3]$, [M]	$D_{Pd(II)}$ values, mL/g			
	4% PVP resin	8% PVP resin	12% PVP resin	4% PVP-Me resin
0.1	18981	31	20	39
0.5	18317	179	50	47
1.0	5872	240	99	68
2.0	8239	311	141	92
4.0	8043	714	259	26
6.0	3407	674	151	15

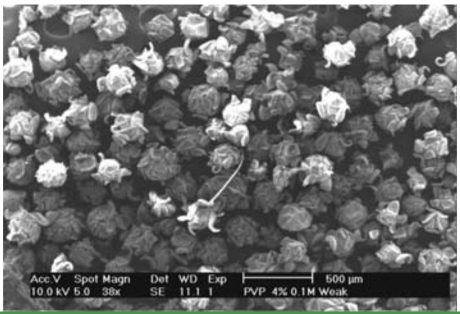


Figure 4 : SEM picture of 4% Pd-PVP resin equilibrated in 0.1 M HNO_3

Conclusions

Several indigenous anion exchange resins were synthesised and evaluated for the recovery of plutonium and palladium. The results of these studies corroborated the suitability of the indigenous resins for the purification of plutonium by anion exchange as well for the recovery of palladium from high level waste solutions. In addition the studies provided an insight into the mechanism of palladium extraction. An optimum cross-linked resin viz., 8% gel-type PVP resin could be identified as the radiation stable candidate for the recovery of radionuclides from various liquid streams encountered in the nuclear fuel cycle.

(Reported by R. Kumaresan, Fuel Chemistry Division, CG)

ISO 9001:2000 Certification to CISF –Kalpakkam

Shri P. Swaminathan, Chairman, Management Review Committee & Director, EIG and Shri S.S.Gusain, Commandant, CISF receiving the ISO 9001:2000 Certificate from Shri. C.S. Venkatesha Murthy, Executive Director, Integrated Quality Certification, Bangaluru.

The Central Industrial Security Force (CISF) at Kalpakkam is responsible for the security of strategic nuclear installations at the project site. The staff strength of CISF is seven hundred and fifty. They are well trained in handling modern security electronic systems covering Automatic Access Control, Intrusion Detection, CCTV, X-ray baggage scanner, Night vision binoculars, Door-frame metal detector, Hand held detectors, Explosive detector and in future to handle Automatic Road Blocker, RFID based vehicle entry and surveillance systems. For ensuring efficient CISF operation, it is necessary to prepare detailed documented procedures and strictly follow the stipulated procedures. Hence it was decided to obtain ISO 9001:2000 Quality Management System Certification for CISF. In this regard M/s Zandig Associates, Bangalore was appointed as consultant for certification and M/S Integrated Quality Certification (IQC), Bangaluru was selected as certifying body. Detailed Quality manual was prepared. Auditors training, Awareness programmes and auditing were conducted by the consultant. The certifying body conducted certifying audit and awarded Certificate for CISF on June 17, 2008.

A function for handing over ISO 9001:2000 certification to CISF-Kalpakkam covering Deployment & Re-deployment, Access control, Intelligence, Communication, Special Task force, Administration, Accounts and Logistics was organized by Management Review Committee (MRC) on October 21, 2008 at IGCAR.

Shri D. Thirugnana Murthy, Management Representative, ISO Certification Committee, IGCAR welcomed the gathering. The process of obtaining certification by CISF was explained by Shri P. Surendranath, Management Representative, Central Industrial Security Force and circulated the quality policy of CISF.

Shri S.S. Gusain, Commandant, CISF explained the importance of ISO Certification in the context of CISF and thanked Dr. Baldev Raj, Director, IGCAR and Management Review Committee members for their cooperation.

Shri C.S.Venkatesha Murthy, Executive Director, Integrated Quality Certification, Bangaluru expressed the need of ISO 9001:2000 QMS in the context of Globalization and the importance for security for premier R&D institutions. He also thanked the management of IGCAR for selecting them as Certifying Body.

Shri P. Swaminathan, Chairman, Management Review Committee emphasized the need of ISO certification and thanked Director IGCAR for his wholehearted support in this certification. Shri G.S. Negi, Inspector, CISF delivered vote of thanks.

(Reported by D.Thirugnana Murthy, Management Representative - ISO Certification Committee, IGCAR}

IAEA Technical Meeting on Fuel Handling Systems of Sodium Cooled Fast Reactors

November 24-27, 2008

Dr. Baldev Raj, Director, IGCAR, Shri S.C. Chetal, Director, REG and Dr. P. Chellapandi, Director SG, during the Technical meeting with the IAEA delegation

Design of fuel handling system has significant impact on the economy in the fast reactors. Design efforts are currently directed towards achieving cost effective designs in order to reduce the unit energy cost for future FBRs. The challenges are to handle and reprocess short cooled fuel, overcome the limitation of opacity of sodium, designing machines/equipment which are highly reliable, leak tight, remotely operated and which will perform well under sodium. In this respect, international collaboration is very important. With the objective of bring together experts to share their experiences in design and operation of fuel handling machines/equipment and to evolve designs with improved reliability & cost effectiveness for future FBRs, a four day technical meeting on "Fuel Handling Systems of Sodium Cooled Fast Reactors" under the auspices of IAEA was held at IGCAR during November 24-27, 2008.

Dr. Alexander Stanculescu of IAEA was the Scientific Secretary for the meeting. Twenty nine delegates including international participants from Belgium, France, and national participants from BARC, AERB and IGCAR attended the meeting. Dr. Baldev Raj, Director, IGCAR inaugurated the meeting and welcomed the participants. In his inspiring inaugural address, Dr. Baldev Raj, Director, IGCAR highlighted that nuclear energy is a key energy resource for India and fast reactors would play a key role in increasing the installed capacity multi fold. The opaque nature of sodium coupled with the need to ensure no physical connection between the control plug and the core prior to fuel handling, reinforces the need for development of ultrasonic scanner. The development of reliable & robust designs working in sodium & sodium aerosol environment, means to reduce fuel handling time, application of probabilistic safety analysis are some of the key aspects which need detailed discussion among experts to arrive at improved solutions.

There were seven technical sessions covering the status of national programmes in various participating countries, design and analysis of fuel handling systems & components and operating experience of fuel handling systems. Presentations were made on the shielding & physics aspects, design, structural analysis, thermal hydraulic analysis and control & instrumentation of fuel handling system for PFBR including the Inclined Fuel Transfer Machine (IFTM) and on the design improvements for future FBRs. The operating experience of FBTR & details of guide tube incident were also presented. The international presentations covered the design of fuel handling system for MYRRHA facility in Belgium, the design & operating experience of fuel handling systems in French FBRs including sodium cleaning & decontamination and the approach for future FBRs in France and the design evolution of fuel handling system in Russian reactors from BOR-60 to BN-1800.

The participants recognized the need for reducing the cost of fast reactors in order to make it economically competitive and fuel handling is identified as a key area for design optimization and cost reduction. In France, taking into account the wealth of experience with fuel handling systems accumulated in Rapsodie, Phenix, SPX-1 and EFR, the design of fuel handling system is being made with the objective to further optimize and reduce cost compatible with the targeted reactor availability of 90% and with the requirement to permit whole core discharge to meet the requirements of sodium draining and inspection of welds in the core support line. Other options under study include use of pantograph machine with slit in control plug for in-vessel handling, use of improved materials (EM10) for subassembly wrapper, provision of in-vessel storage and ex-vessel handling by flask with provisions for adequate subassembly cooling during handling, provision of ex-vessel sodium storage or provision of multiple subassembly washing pits. The meeting concluded summarizing the design and operating experiences of fuel handling systems and after identification of proposals for future collaboration.

(Reported by P. Chellapandi, Nuclear Engg. Group, REG)

Interaction Session of Dr. Alain Bugat, *Chairman,CEA* and Dr. Anil Kakodkar, *Chairman, AEC* with Trainee Scientific Officers and Research Scholars of IGCAR

December 2, 2008

It was a very rare and momentous occasion when the icons of French Atomic Energy Agency, Dr.Alain Bugat, Chairman, CEA and Indian Atomic Energy, Dr.Anil Kakodkar, Chairman, AEC jointly addressed the student community of IGCAR. The meeting started with Dr.Baldev Raj, Director, IGCAR welcoming the gathering.

Dr.Anil Kakodkar, Chairman, AEC, recalled that development of Human Resources has taken the center stage in the programmes of DAE. He felt the CEA is an excellent role model and France leads the world map in Nuclear Energy production with 80% of its energy needs from nuclear origin.

France had a sustained closed fuel cycle policy from the beginning. Implementation of the closed fuel cycle policy is important for India too. The cooperation of India and France is the oldest and the first has been in the area of Fast Reactors. France and India have also been working together for a number of years in the area of safety of Fast Reactors. R&D has been an important part of the cooperation, which is working at the level of academics and student exchange.

Dr. Alain Bugat, the leader of the French Atomic Energy Programme, endorsed the view of Dr. Anil Kakodkar that the cooperation between France and India is oldest and dates back to 1950s. He felt that France and India are in a “win-win” situation as the safety and public acceptance levels are much higher here. India is bestowed with expertise in Nuclear Energy and hence it is a matter of great pleasure to have it in the nuclear community as a big nation. We are facing the revival of nuclear energy without doubt, owing to the troubles of climate change. Nuclear energy is not a complete solution but still we do not have a credible solution without nuclear energy. The lessons learnt from Chernobyl and Three-mile island have implied about one or two orders of magnitude enhancement in safety, strong improvements to develop closed fuel cycle technology and to reduce the radiotoxicity of the waste and spent fuel to 300 years. The extraction of minor actinides reduces the time frame of radiotoxicity. The fuel reprocessing technology has undergone development by way of new design and with improved levels of safety. In the rapidly changing political and economical scenario, it is difficult to build only nation-specific programmes. Nations are becoming interdependent and the cost of research facilities is high. The budget is not elastic, which puts in a lot of pressure and a collective initiative is required to develop new programmes, hence more countries are bringing up facilities by co-operation and each country would retain specific characteristics in them. Transport of nuclear materials and intellectual property rights are other issues one needs to address to.

Dr. Alain Bugat felt that we can sustain only by pursuing highest levels of science and the highest level of science is a characteristic of nuclear energy. The consent of society by way of public acceptance to the programmes is also essential. We need to explain to the public about the safety practices adopted in nuclear programmes. It is a very important yet difficult and an extraordinary challenge when the older generation is leaving. Every country is looking for scientists and engineers and India has a broad capability towards this. Safety and public acceptance are the important issues to be addressed while planning for future nuclear programmes.

Discussion with Dr.Alain Bugat (Dr. AB)

Q.1: Is the nuclear energy a unique solution to the energy needs?
Dr. AB: 80% of the needs of energy in France are met from nuclear resources. We have realized that it was a good choice. Our path of challenge is to have 20% of energy needs of Europe to be coming from nuclear sources. Today we are interested in localized energy potentials. Energy need not be necessarily centralized.

Q.2: What is the progress in fusion reactor?
Dr. AB: ITER programme is progressing well with a target date of 2018. It is a demonstration device. The last quarter of this century can see fusion playing a major role.

Q.3: In view of the changed circumstances, we can say that our country cannot grow alone. In what ways is the collaboration between India and France addressing this?
Dr. AB: Nuclear programmes can be initiated by developing and developed countries alike.

Q.4: In what way is France benefiting by the collaboration with India?

Dr. AB: Collaboration will signal a buzz of activity in France where there is already a pressure on the economy. 'AREVA', a company with major stake held by CEA, is looking for selling reactors to India.

Q.5: France derives 80% of its energy demand from nuclear sources. How do people in France take this?

Dr. AB: People in France are not afraid of staying near nuclear plants and that is why we could build many. Their only concern is on waste management. CEA spends about 45 million euros on R&D to improve waste management and work out better strategies for decommissioning the plants.

Q.6: Global warming will lead to rise in mean sea level and since most of the nuclear plants are situated near sea shore, how is this problem taken care of?

Dr. AB: Plants are normally constructed at elevations of about six to seven meters above nominal sea level to take into consideration about Tsunami, Cyclone etc. Rise in sea water level will be in centimeters. Thus, this shall not manifest in the form of a threat or accident.

Vote of thanks was proposed by Dr. M. Sai Baba, Head, S&HRPS.

(Reported by M. Sai Baba, S&HRPS)

Consultancy Meeting of INPRO Collaborative Project on Integrated approach for the modeling of safety grade decay heat removal system for liquid metal reactors

December 3-5, 2008

The first consultancy meeting for INPRO collaborative project on "Decay Heat Removal system for Liquid Metal Reactors" was held at IGCAR, Kalpakkam on December 3-5, 2008. The main objective of the project is the inter-comparison of results of decay heat removal system of a sodium cooled fast reactor. The meeting was attended by representatives from IAEA, India, Korea and Russia. Dr. Baldev Raj, Director, IGCAR inaugurated the meeting and stressed the importance of this collaborative project to result in a robust decay heat removal system for fast reactors. Presentations were made on the progress of the project, general considerations on calculation features, modeling, benchmarking approach and future plan of activities.

Participants of IAEA INPRO Collaborative project meeting with Shri S.C.Chetal, Director, REG, Dr. P.Chellapandi, Director, SG & Associate Director, NEG and senior colleagues of the Centre

(Reported by P. Selvaraj, Mechanics & Hydraulics Division, REG)

Meeting of Prof. Georges Vendryes and Mrs. Inge Vendryes with Trainee Scientific Officers and Research Scholars

December 5, 2008

Prof. Georges Vendryes, former Executive Director, CEA, France and Mrs. Inge Vendryes visited the Training School hostel premises on December 5, 2008 (Friday) at 19.00 hrs and interacted with TSOs and Research Scholars. The interaction session started with a formal introduction of Prof. Vendryes and Mrs. Inge Vendryes by Dr. M. Sai Baba, Head, S&HRPS.

Prof. Vendryes initiated the discussion with an informal lecture broadly touching upon his experience in the nuclear programme of France for several years.

"I am happy to talk to you all. At Kalpakkam, I feel at home. I am envious of you all for two reasons; one being that you are young, energetic and full of enthusiasm. Second being that it happens that you will soon start a professional life at a special auspicious moment when mankind is moving towards revival of nuclear energy. India will play a major role in this nuclear renaissance. In France we will also be starting many new programmes but those will be at a slower pace. Revival of nuclear energy is more important for countries like India and China, more specifically to India. I am convinced that the Government, DAE and the industry are preparing towards that. In light of this, very interesting opportunities are likely for India.

India was isolated from the nuclear mainstream in the past. For almost thirty years India was working in isolation with no possibility of scientific exchange. The agreement between France and India on September 30, 2008, will lead to many more collaborations in the coming years. I think you are all starting to take part in various activities, joint ventures etc. at a very appropriate/auspicious moment. Nuclear energy is unique for posing challenges in scientific, industrial, economical and political issues. There are very interesting subjects to work in nuclear energy.

I turned twenty five on February 1946. I was a young civil servant working for the French government and expected to spend a whole life there. One of my professors explained the concept of fission and I was so excited that I changed my orientation and decided to work for the nuclear programme and joined the CEA. I do not have any regret and hence request you to go the nuclear way as the future is for nuclear energy".

Discussion

Q.1: What made you think of Fast Breeder Reactors?

Prof.Vendryes: During the last three and half decades that I have worked on FBR and I felt this is the best concept. Why? If you use Uranium/enriched Uranium you can perhaps fuel the reactors for a century. Only way to sustain the nuclear programme is by way of breeding, which is the gift of nature. Breeding increases the sustainability of the programme by a factor of hundred. We can use the resources (uranium) in a better way. Breeding is the future of nuclear energy. No wonder France is pursuing a few type of reactors of GEN IV, which are breeders. Breeder is the ultimate of fission.

Q.2: How do you look at India as a nuclear power?

Prof.Vendryes: I must tell you that I admire very much what DAE and Indian industry has done since beginning. Dr.Homi Bhabha had the vision of nuclear energy for India. I have been closely watching the development of nuclear energy in India. It appeared initially that India was very far from development. But in the last twenty years, tremendous improvements have taken place. Now I can say that India has mastered its development in PHWR. This can be used for breeder. This experience will be useful for design and construction of reactors within reasonable time and budget. I admire the progress achieved in isolation. It is not good situation to work alone. Now you can work with an equal footing. The fact that you are obliged to develop in isolation, with possibly extra difficulties, but it had advantages. It has solution to problems on its own. You have turned the difficulty into an asset.

Q.3: We are dumping a lot of "unused heat"(heat not exploited for energy production). How can this be used?

Prof.Vendryes: Question is economical feasibility. The heat can be used for industrial purposes. We have to find a good market wherein there is a balance between the heat generated and the demand.

Dr.MSB: We are having the NDDP working with such "unused heat". This heat is used for desalination. In cold countries this heat can be utilized for home heating and all other heating purposes.

Q.4: You have started your career in 1946. Were you not worried to take up a career in nuclear energy in the aftermath of dropping of atom bombs during world war II in 1945?

Prof.Vendryes: Nuclear energy is used by people for destructive purposes as well. I had decided to work only for peaceful purposes. I was given an opportunity to work for a project leading to produce atomic bombs which I declined. Our CEA does have programmes for military and strategic purposes but I have never been associated with the same. I was determined to work for using this energy for peaceful purposes.

Q.5: Did you not have any compulsion from your government for refusing to work for producing the bomb?

Prof.Vendryes: No compulsion, absolutely free.

Q.6: Some people feel that Nuclear energy is also responsible of global warming. What is your view?

Prof.Vendryes: Nuclear energy involves low temperature heat being sent to condenser as in coal burning but this form of energy is devoid of any pollution.

Q.7: What about radioactive waste that causes pollution?

Prof.Vendryes: We know how to contain the highly active waste in glass matrix and place in containers under the ground. Pessimistic evaluation of what could happen after one thousand years can be worked out. We are adding more waste with time, but the amount of waste generated is very less. The waste generated for providing energy for an average French family of five, living for seventy years can be stored in a match box.

Q.8: How will the world face the transition from FBR to thorium reactor?

Prof.Vendryes: India has lots of thorium and the ultimate aim of the programme should be to burn the thorium. When there is enough uranium, this question does not arise. Utilisation of thorium involves a very lengthy development of process and technology. Dr. Homi Bhabha has perceived a strategy which is justified till date. It will take time to have a thorium reactor.

Q.9: Can nuclear programme be privatised?

Prof.Vendryes: It is a bit difficult for me to answer this question. Nuclear energy has developed so well because of the political will. In India it is rightly in the hands of the Government, otherwise you would not have seen so much of achievement. Even if private parties take up the nuclear programme, Government should have a tight control. In France, AREVA is a major player but Government is its major stake holder. French Government keeps a tight control on its programmes.

Q.10: Can you describe the French Atomic Energy programme?

Prof.Vendryes: About 80% of energy needs of France are met from nuclear sources and about 10 - 15% from Hydel sources. There is no proposal for building new plants, the thrust is on towards replacement of existing plants that are working beyond their designated lifetime.

Q.11: Could you please forecast ways by which we students can visit France for pursuing higher studies?

Prof.Vendryes: I would be happy to help you to come to

France. An active collaboration between India and France would start soon. After thirty years of independent programmes, we are going to work together. Dr.Alain Bugat and Dr.Anil Kakodkar have reviewed the collaborations and soon new areas of interactions can develop.

Dr.MSB: One of the agendas of a recent CEA-DAE was to discuss on issues on possibilities of exchange of students between the two countries.

Q.12: Now it is the age of nuclear fusion. In this scenario how best can we use uranium and thorium?

Prof.Vendryes: I am extremely skeptical about producing significant amount of energy from fusion. For me it is obvious that it will not take place before the end of this century. Plasma physics theory and experiments have concluded on fusion but I have no hope that I would see fusion.

Q.13: How do you feel after witnessing the blasts at Taj?

Prof.Vendryes: I cannot understand how people can put their own life to risk to harm others. Such people cannot be prevented. People are doctrined to do this.

Q.14: Why Super Phenix is not in operation?

Prof.Vendryes: It was a very sad decision. It was shut down based on electoral agreement between social and green party. Green party is against FBR and has been fighting against Nuclear energy programmes. EGF has got instructions to stop it and demolish it.

Q.15: Is there more danger to nuclear reactors because of the rise of terrorism?

Prof.Vendryes: It is not so easy to gain access inside the reactor. Special precautions are to be actuated in various facilities. We ought to be realistic. We can take stock of the situation but the measures taken are confidential.

Mrs. Vendryes sharing her view with the students mentioned that Fast reactors have been their life. I encourage you to take up this career. Nuclear programme needs to be utilized for peaceful purposes.

(Reported by M. Sai Baba, S&HRPS)

25th DAE
Safety and Occupational Health Professionals' Meet

December 18 – 20, 2008

The 25th DAE Safety and Occupational Health Professionals' Meet (DSOHPM) was held at Safety Research Institute (SRI), Convention centre, Anupuram during December 18 – 20, 2008. The meet was jointly hosted by Atomic Energy Regulatory Board (AERB) and DAE units at Kalpakkam (IGCAR, MAPS, BARC(F) & BHAVINI). The theme of the meeting was: Safety Management, Safety Culture and Industrial Medicine.

Shri S.K.Sharma, Chairman, AERB inaugurated the meet. The inaugural function was presided over by Dr. Baldev Raj, Director, IGCAR. A booklet on "Safety Culture & Safety Management" was released by Dr. S.K.Jain, Chairman & Managing Director, NPCIL & BHAVINI during the occasion.

Shri S.K.Sharma, Chairman, AERB presented the "Green Site Award" to Dr. Baldev Raj, Director IGCAR for DAE units of Kalpakkam and to Shri S.Narayanan Kutty Head, IREL, Manavalakurichi, Tamil Nadu.

Nine invited lectures and sixty papers were presented during the meeting. The technical session consisted of three plenary sessions, four parallel sessions & one technical poster session. The sessions covered the topics on safety management, safety culture, health & safety management of confined space entry, safety management models and applications, occupational health & behavior based safety aspects.

About three hundred and fifty delegates/participants from various DAE units attended the meet. The winners for the poster, cartoon, logo & slogan competitions were awarded prizes during the inaugural and valedictory functions.

(Reported by G. Rajasekar, Member Secretary, 25th DSOHPM)

Dr. Baldev Raj, Director, IGCAR delivering the inaugural address. Also seen in the picture are Dr.S.K.Jain,Chairman and Managing Director of NPCIL & BHAVINI, Shri S.K.Sharma,Chairman, AERB and other senior colleagues of DAE

CHEMQUEST 2008

Every year the southern regional chapter of the Indian Association of Nuclear Chemists and Allied Scientists (IANCAS(SRC)) organizes a "Curie Memorial Lecture" on a popular topic that brings out the high impact contributions made in nuclear sciences and radiochemistry to the society. These lectures also highlight the advances made both in the fundamental as well as applied areas of nuclear science. In order to extend the reach of such endeavours that are meant to popularize science, this year IANCAS(SRC) started a new initiative, to instill interest in students to pursue careers in science, by conducting a quiz programme named "CHEMQUEST". A preliminary written test for screening, "ScienceQuest 2008" was conducted at the Maharishi Vidya Mandir, Chennai on November 29, 2008. About hundred and twenty students from over forty schools in and around Chennai, participated in this programme out of which about sixteen teams comprising thirty two students were selected to participate in the CHEMQUEST, conducted at IGCAR on December 1, 2008. About ten teachers also accompanied these students. The first four teams of the CHEMQUEST were awarded citations and cash prize, sponsored by the Radiochemistry Excellence Promotion Trust. Dr. Baldev Raj, Director, IGCAR gave away these prizes and addressed the students. In his address, he urged the students to take up a career in socially purposeful scientific research. All the participants of the quiz also visited the Radiochemistry Laboratory, IGCAR and were benefited by the Curie Memorial Lecture by Dr.S.F.D'Souza, Associate Director, Bio-Medical Group, BARC, on the "Role of Nuclear Technology in Food Security". A feed back session was held at the end of the day's programme. Many of the participants expressed interest in knowing more about the research activities of this Centre. The ScienceQuest and CHEMQUEST were conducted with the active participation of the Public Relations and Information Committee, IGCAR.

(Reported by T.G. Srinivasan, CG)

visit of dignitaries

The 6th CEA-DAE Coordination meeting was held at IGCAR, Kalpakkam during December 2-3, 2008. The CEA delegation was led by Dr.Alain Bugat, Chairman, CEA and the Indian delegation was led by Dr.Anil Kakodkar, Chairman, AEC. The CEA team visited Fast Breeder Test Reactor, facilities in Safety Group, Fast Reactor Technology Group, Laboratories in Materials Science Division, Structural Mechanics Laboratory, Nuclear Desalination Development Plant and the construction site of Prototype Fast Breeder Reactor.

Dr. Alain Bugat, Chairman, CEA, Dr. Anil Kakodkar, Chairman, AEC, Dr. Baldev Raj, Director, IGCAR, Dr. S. Banerjee, Director, BARC and senior colleagues of the Centre with the visiting French delegation

Delegation from Japan Atomic Industrial Forum headed by Mr.Takuya Hattori, President, Japan Atomic Industrial Forum along with Dr. P.R. Vasudeva Rao, Director, Chemistry, Metallurgy and Materials Groups and senior colleagues of the Centre and Nuclear Power Corporation of India Limited

The Japan Atomic Industrial Forum headed by its President, Mr.Takuya Hattori, visited the Centre during November 27-29, 2008 to hold discussions with the Director and other senior colleagues of the Centre.The team visited Fast Breeder Test Reactor, Hot Cells, Laboratories in Non-Destructive Evaluation Division, facilities in Fast Reactor Technology Group, Structural Mechanics Laboratory, Madras Atomic Power Station and the construction site of Prototype Fast Breeder Reactor.

Prof. Seeram Ramakrishna, Vice-President (Research Strategy), National University of Singapore, Singapore

Prof.Seeram Ramakrishna, Vice-President (Research Strategy), National University of Singapore, Singapore, visited the Centre and met Dr.Baldev Raj, Director, IGCAR and other senior collegues of the centre on December 24, 2008. He visited the Fast Breeder Test Reactor, Hot Cells, Laboratories in Non-Destructive Evaluation Division, Chemistry Group, Safety Group, Materials Science Division and the PFBR construction site.

Students visit to IGCAR

- Forty Nine Officers from the 'Flying Instructors School', Air Force Station, Tambaram visited on October 7, 2008.
- Twenty Four Trainee officers from 'INS Zamorin', Kannur, Kerala visited on October 10, 2008.
- Officers from the 'Ground Instructor's School', Tambaram, visited on October 15, 2008.
- Staff members and students from 'The School', Chennai, visited on October 21, 2008.
- Faculty and students from 'Sri Ramachandra Medical College of Management', Chennai visited on November 3, 2008.
- Fifty Seven higher secondary students from the 'Kendriya Vidyalaya', Central Leather Research Institute, Chennai accompanied by their teachers visited on November 12, 2008.
- Staff members and students from 'GS Hindu School', Srivilliputhur, Tamil Nadu visited on November 26, 2008.
- Faculty and students in Metallurgy from 'Banaras Hindu University', Varanasi visited on December 8, 2008.

Awards & Honours Congratulations

Department of Atomic Energy has instituted annual awards for excellence in Science, Engineering and Technology in order to identify best performers in the area of Research, Technology Development and Engineering in the constituent units (other than Public Sector Undertakings and Aided Institutions). The Young Scientist, Young Engineer, Young Technologist, Homi Bhabha Science and Technology Award and Scientific and Technical Excellence Award fall under this category. Group Achievement awards for recognition of major achievements by groups have also been instituted. Life time Achievement Award is awarded to one who has made significant impact on the DAE's programme. They are the icons for young scientists and engineers to emulate. The awards consist of a memento, citation and cash prize.

The recipients of the awards from IGCAR for the year 2007 are:

Homi Bhabha Science and Technology Award

Dr. B. Venkataraman, Quality Assurance Division, Engineering Services Group

Scientific and Technical Excellence Award

Shri V. Rajan Babu, Reactor Components Division, Reactor Engineering Group

Dr. N.V. Chandra Shekar, Materials Science Division, Metallurgy & Materials Group

Dr. K. Devan, Reactor Physics Division, Reactor Engineering Group

Dr. R. Sridharan, Liquid Metals & Structural Chemistry Division, Chemistry Group

Young Engineer Award

Shri Chittaranjan Das, Materials Technology Division, Metallurgy and Materials Group

Shri K. Natesan, Mechanics & Hydraulics Division, Reactor Engineering Group

Shri V. Vinod, Sodium Facilities Division, Fast Reactor Technology Group

Shri Sumantra Mandal, Materials Technology Division, Metallurgy and Materials Group

Young Technologist Award

Shri Manoj Kumar Mishra, Electronics & Instrumentation Division, Electronics & Instrumentation Group

Meritorius Services Award

Shri N.S. Thambi, Mechanical Metallurgy Division, Metallurgy and Materials Group

Shri A.G. Sarangapani, Central Workshop Division, Engineering Services Group

Shri G. Moorthy, Air-conditioning and Ventilation Systems Division, Engineering Services Group

Shri K. Victor Arulraj, Engineering Services Division, Engineering Services Group

Group Achievement Awards

Development of Electrochemical and Solid State Gas Sensors

Dr. T. Gnanasekaran, Dr. R. Sridharan, Shri K.H. Mahendran, Shri S. Nagaraj, Smt. Kitheri Joseph, Smt. Manjulata Sahu, Dr. Rajesh Ganesan, Shri Sajal Ghosh, Shri G. Ravishankar, *Liquid Metals & Structural Chemistry Division*, Shri K. Dayalan, Shri A. Veerapandian, Shri V. Sureshkumar, Smt. S. Premalatha, Shri R. Parthasarathy, Shri K.C. Srinivas, *Chemical Facility Division*, Smt. K. Sujatha, *Fuel Chemistry Division*, Chemistry Group, Shri S. Bagavathiappan, *Non-Destructive Evaluation Division*, Shri C. Subramanian, *Central Workshop Division*, Shri K.M. Natarajan, Shri P. Balakrishnan, Shri P. Shanmugam, *Engineering Services Group*, Shri I.B. Noushad, Shri S. Kishore, Shri B. Muralidharan, *Sodium Facilities Division* and Shri Vivek Nema, *Sodium Technology & Thermal Hydraulic Division*, Fast Reactor Technology Group

Seismic Design and Qualification of PFBR Components

Dr. P. Chellapandi, *Nuclear Engineering Group*, Shri R. Srinivasan, *Nuclear Engineering Group*, Shri T. Selvaraj, *Mechanics & Hydraulics Division*, Shri S.D. Sajish, Shri C. Raghavendran, Shri P. Ravi, Shri Vankatiah, Shri V. Kothandam, Shri V. Devaraj, Shri R. Manu, *Nuclear Engineering Group*, *Reactor Engineering Group* and Shri Jagannath Mishra, *Safety Research Institute*, Atomic Energy Regulatory Board.

Design, Development, Manufacture & Qualification ofControl & Safety Rod and its Drive Mechanism for PFBR

Dr. P. Chellapandi, *Nuclear Engineering Group*, Dr. D. Rangaswamy, *Power Plant Control Division*, Shri V. Rajan Babu, Shri P. Puthiyavinayagam, Smt. R. Vijayashree, Shri T.S. Paneer Selvam, Shri K. Krishnaprasad, Shri S. Jaisankar, Shri P.A. Sasidharan, *Reactor Components Division*, Nuclear Engineering Group, *Reactor Engineering Group* and Shri C. Meikandamurthy, Shri K. Gurumoorthy, *Sodium Facilities Division*, Shri D. Ramdasu, Shri G.K. Pandey, Shri Ajesh Kumar, *Separation Technology & Thermal Hydraulic Division*, Shri R. Veerasamy, Shri S.C.S.P. Kumar Krovvidi, Shri Sudheer Patri, Shri S.K. Dash, Shri T. Logaiyan, *Components & Instrumentation Development Division*, Fast Reactor Technology Group, Shri E. Venkatesan, *Quality Assurance Division*, Engineering Services Group and Shri B. Saha, *Electronics & Instrumentation Group*

Post Irradiation Examination of Fuel & Structural Materials at FBTR

Shri K.V. Kasiviswanathan, Shri V. Venugopal, Shri N. G. Muralidharan, Shri N. Raghu, Shri C.N. Venkiteswaran, Shri V. Karthik, Shri V. Anandaraj, Shri M. Sekar, Shri R. Parthasarathy, Shri M. Ramanathan, Shri Jojo Joseph, Shri T. Johny, Shri Shaji Kurien, Shri A. Vijayaragavan, Shri T. Ulaganathan, Shri D. Ganesan, Shri V.L. Balakrishnan, Shri S. Maharajan, Shri N.P. George, Shri K. Satheesh Kumar, Shri R. Subramanian, Shri N. Kulasegaran, Shri Y. Ramaseshu, Shri B. Venugopal Naidu, Shri S. Kumaresan, Shri J. Seenuvasan, Shri R. Devarajulu, Shri P.R. Venkatesan, *Group for Remote Handling, Robotics, Irradiation Experiments and PIE (GRIP)*, Metallurgy & Materials Group and Ms. B. Sasi, Dr. T. Saravanan, *Non-Destructive Evaluation Division*, Metallurgy & Materials Group

Awards & Honours

Congratulations

- **AERB Green Site Award – 2007** has been awarded to the **Kalpakkam Site (IGCAR, MAPS, BHAVINI & Other Units)** by **Atomic Energy Regulatory Board.**

- **Dr. Baldev Raj**, Director, IGCAR has been awarded **Prof. Jai Krishna Memorial Award** by the Indian National Academy of Engineering for the year 2008.

  He has also been awarded with the **Distinguished Materials Scientist Award** by the Materials Research Society of India for the year 2009.

  He has been selected as the **Vice President, Academia NDT International** and **Vice President (Academic, Professional & International Affairs)** of the **Indian National Academy of Engineering (2008-2011)**.

  He has been designated as **Member, Editorial Board** of ‘***Steel Technology’*** and **Member, Editorial Board** of **“Asian Journal of Professional Ethics & Management”**.

- **Smt. Uma Seshadri**, Head, Planning Division, IGCAR has received the **“Women Engineers Award”** for the year 2008 of Institution of Engineers (India) Tamil Nadu State Centre for her outstanding contribution in Engineering Profession.

- **Dr. Anish Kumar**, Non - Destructive Evaluation Division, MMG has been awarded **“Young Scientist Award”** for the year 2008 by the Indian Society for Non Destructive Testing.

- **Shri T. Karthikeyan**, Physical Metallurgy Division, MMG has been awarded **“INAE Young Engineer Award”** for the year 2008.

- **Shri M. Krishnamoorthy,** Central Workshop Division, ESG has been awarded **“Best Welding Engineer”** by the Indian Institute of Welding, Chennai Branch.

- **“Moon Quality Circle”** Zonal Workshop Section, Components & Instrument Development Division, FRTG led by Shri T.V. Maran with members Shri K. Mohanraj, Shri R. Rajendran, Shri A.T. Loganathan, Shri A. Ramamoorthy, Shri D. Kuppuswami and Shri A. Anthuvan Clement has won **Excellence Award** for their Project “ROBOA (Reduction of Breakdowns of all cut machine) at the National Convention for Quality Circles **NCQC – 2008.**

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