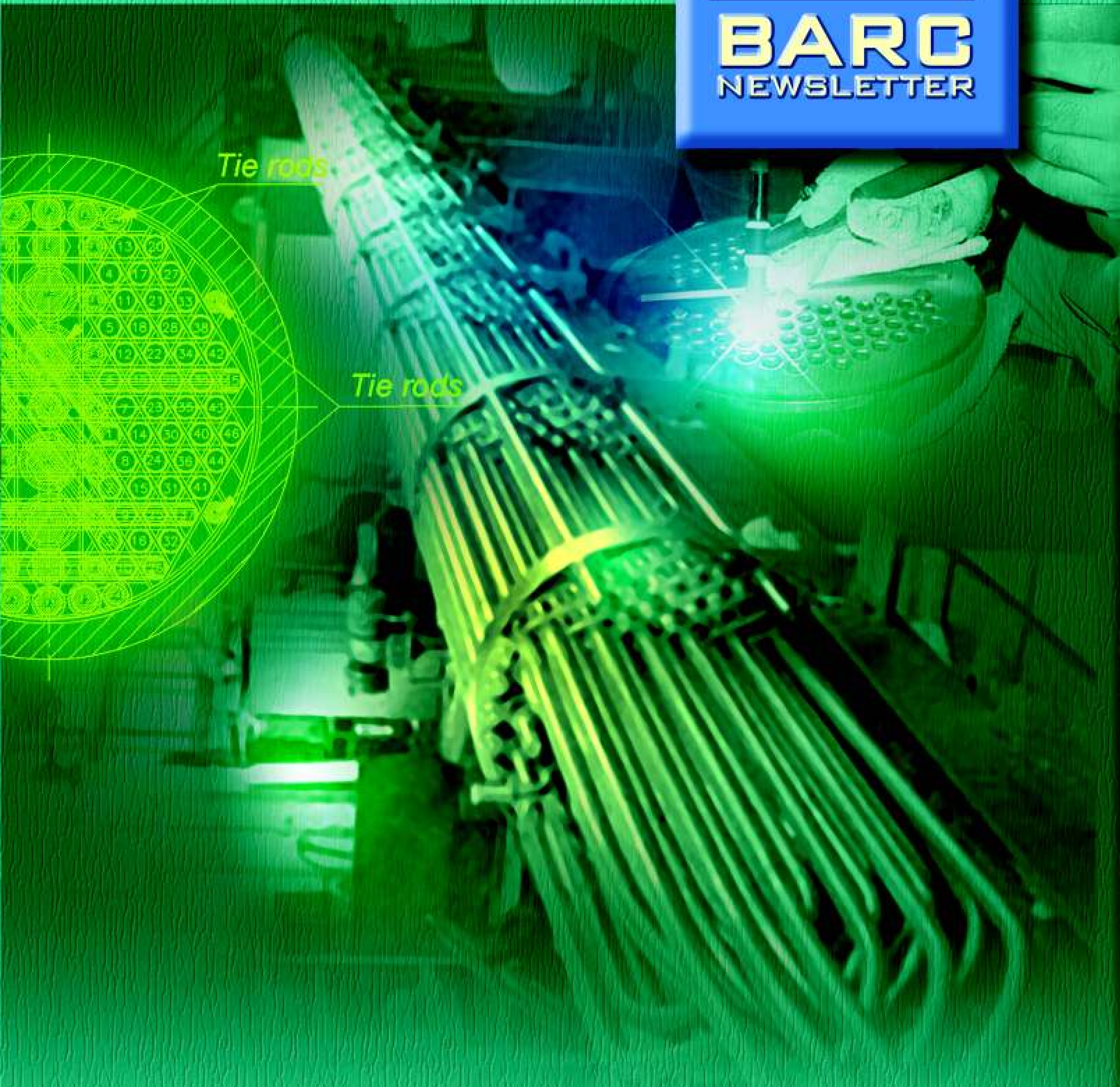
ISSUE NO. 294 | JULY 2008

बीएआरसी न्यूज़लैटर
BARC NEWSLETTER



IN THIS ISSUE

SEPARATION OF HIGH PURITY RARE EARTH ELEMENTS FOR NUCLEAR APPLICATIONS

MANUFACTURE OF INSTRUMENTED STEAM GENERATORS FOR FISBE PROJECT

In the next issue

Development of a radioisotope guided surgical gamma probe for early detection and management of breast cancer

Breast Cancer is the most common type of cancer amongst women. Early detection is crucial in the control and treatment of the disease. Biopsy is used, to accurately detect the Sentinel Lymph Node (SLN), which is the first node where cancer cells are found. The Isotope Applications Divn., has developed a compact, micro-controller-based radioisotope guided SLN detection system. The system consists of a measurement and control unit and a hand-held probe. The description of the system, clinical performance evaluation of the system and results of the trials conducted at the Rajiv Gandhi Cancer Institute and Research Centre, New Delhi, are covered in this article.

CONTENTS

URL:http: //www.barc.gov.in

SEPARATION OF HIGH PURITY RARE EARTH ELEMENTS FOR NUCLEAR APPLICATIONS

H. Singh, R. Vijayalakshmi and M. Anitha
Rare Earths Dev. Sec., Materials Group

High purity Rare Earth Elements (REE) find applications in the nuclear field [1] , particularly in existing PHWRs and the proposed AHWR reactors and in areas such as phosphors for luminescent applications.

For nuclear reactor control applications, Boron is often used. But it has the disadvantage that the (n,α) reaction involved, produces gaseous by-product that has a deleterious effect on fuel stability. Rare earths such as Gadolinium and Dysprosium involve (n, γ) reactions and are free of such disadvantages. For TAPS 3 and 4 gadolinium nitrate ($Gd(NO_3)_3.6H_2O$) has been used for reactivity control, through moderator liquid poison system as well as for reactor shut down system. A low concentration of Gadolinium in heavy water, 0.1-0.2 g/l, is sufficient to shutdown the reactor in a short time. The data on isotopes of naturally occurring Gadolinium and Dysprosium and their neutron absorption cross-section is given in Table 1 [2]. The average neutron cross-section is 46000 barn, which is high enough for rapid and efficient control. Hence it is preferred over boron. The material used for reactor application must meet stringent specifications: purity >99.9%, Na <100 ppm, Mg < 50 ppm, Cl <50 ppm. Over 150 kg of this material was prepared at REDS and supplied to NPCIL.

Dysprosium oxide admixed and pelletized with Zirconium oxide, is proposed to be used in AHWR central rod, for the purpose of maintaining negative

Table 1: Nuclear data of naturally occuring Dy and Gd

Isotope		Natural abundance (%)	Neutron absorption cross-section (σ) in barns
Dy	156	0.06	33
	158	0.1	43
	160	2.34	56
	161	19	600
	162	25.5	194
	163	24.9	124
	164	28.1	2840
Gd	152	0.2	735
	154	2.1	85
	155	14.8	61100
	156	20.6	1.5
	157	15.7	259000
	158	24.8	2.2
	160	21.8	0.77

void coefficient. It's neutronic properties are also given in Table 1, which show that it is a slow burner. Dysprosium oxide for AHWR application needs to confirm to specifications such as : Lighter Rare Earths (LRE) <0.1%, Gd_2O_3<0.2%, Tb_4O_7<1%, Y_2O_3 : 1.5 – 5% and Dy_2O_3 ~95%.

Terbium is a vital element of luminescent phosphors (such as $Gd_2O_2S: Tb^{3+}$) which have been developed at REDS. Material purity required for such an application is ~99.9%.

The three oxides of REE discussed above occur together in nature, along with other lanthanides and Yttrium. Their separation from various mixed crude feed stocks into products of required purity, forms the subject of this paper.

Generalized Separation Scheme

The separation of REE with similar chemical properties is a challenging task. It is achieved by using the process of solvent extraction (SX) in a large number of separation stages in a complex process circuit. The overall paradigm of separation is shown in Fig. 1. Basic approach is to selectively separate one REE after another, while producing by-products that form feed-stock for further separations. The Gadolinium Separation System (GSS), the Dysprosium Separation System (DSS) and the Terbium Separation System (TSS) all have several features of generic nature in common. Theseare discussed first. The separations are based on extraction of REE from aqueous phase into an organic phase, containing an extractant of liquid cation exchanger type: di (2-ethyl hexyl) phosphoric acid (EHEPHA). The extraction mechanism at low loading, [REE]/[EHEPHA] < 0.14 and acid concentration < 5M can be describedas :

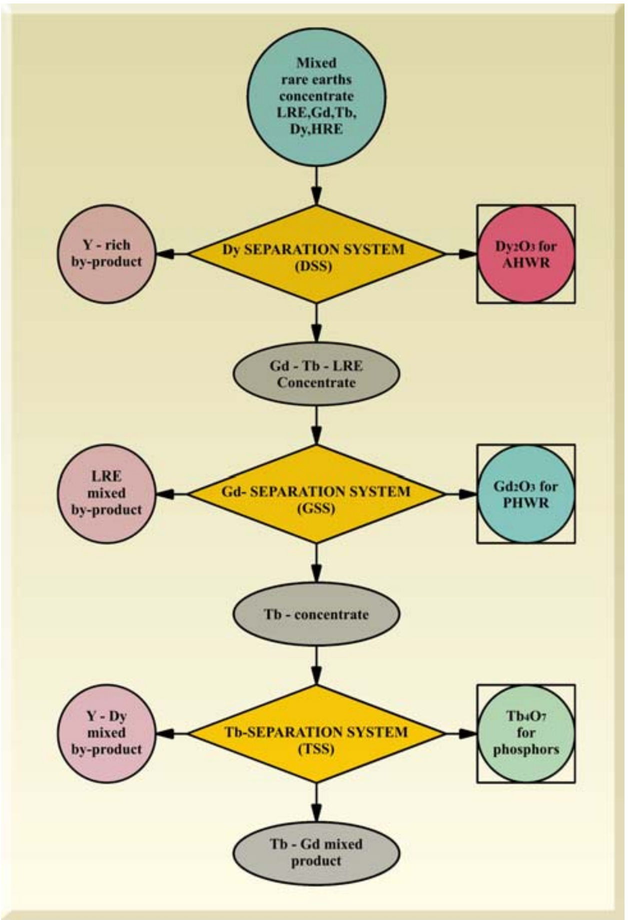


Fig.1 : Paradigm for the separation of high purity rare earth elements

$$RE^{3+}_{(aqueous)} + 3(HR)_{2(organic)} = RE\ (HR_2)_{3\ (organic)} + 3H^{+}_{(aqueous)}$$

where $(HR)_2$ is the dimeric form of EHEHPA, RE^{3+} is a trivalent rare element ion and subscripts aqueous and organic, denote the phases in which the species are present.

The sequence in which various individual REE are extracted by EHEHPA from an acidic medium is as follows :

La < Ce < Pr < Nd < Sm < Eu < Gd < Tb < Dy < Ho < Y < Er < Tm <Yb < Lu.

This sequence provides the logic for the development of a 'dual – cycle extraction process' which is a common feature of DSS, GSS and TSS. It is schematically shown in Fig. 2. In this process, the desired element of interest is the 'key' element K. Depending upon application, it could stand for Dy or Tb or Gd. The REEs that have a better extraction than the key element, are selectively extracted in the first cycle. The key element is left in the aqueous raffinate phase of the first cycle, which forms the feed for the second cycle. Operations of precipitation and re-dissolution are incorporated if needed for water balance and acidity control. In the second cycle, the key element is preferentially extracted into the organic phase, while leaving the less extracted lighter REE in the aqueous phase.

Each of the two cycles has cascades of counter-current stages of extraction, scrubbing and stripping. Separation factor (β) between adjoining rare earth elements [3] is low e.g. $\beta_{Gd/Eu}$ = 1.57, $\beta_{Dy/Tb}$ = 2.7 and $\beta_{Ho/Dy}$ = 1.8. (Note that separation between elements 1 and 2, is defined as $\beta_{12} = D_1/D_2$ where D_1 and D_2 are the distribution ratios of individual rare earth elements.) As a result of low b, scrubbing is essential to back-wash the co-extracted element into aqueous phase. The scrubbing medium is diluted hydrochloric acid. Where a very high purity is needed, the scrubbing medium also contains part of the pure product in an operation called 'refluxing'. Refluxing is adopted in the second cycle where the final product is obtained.

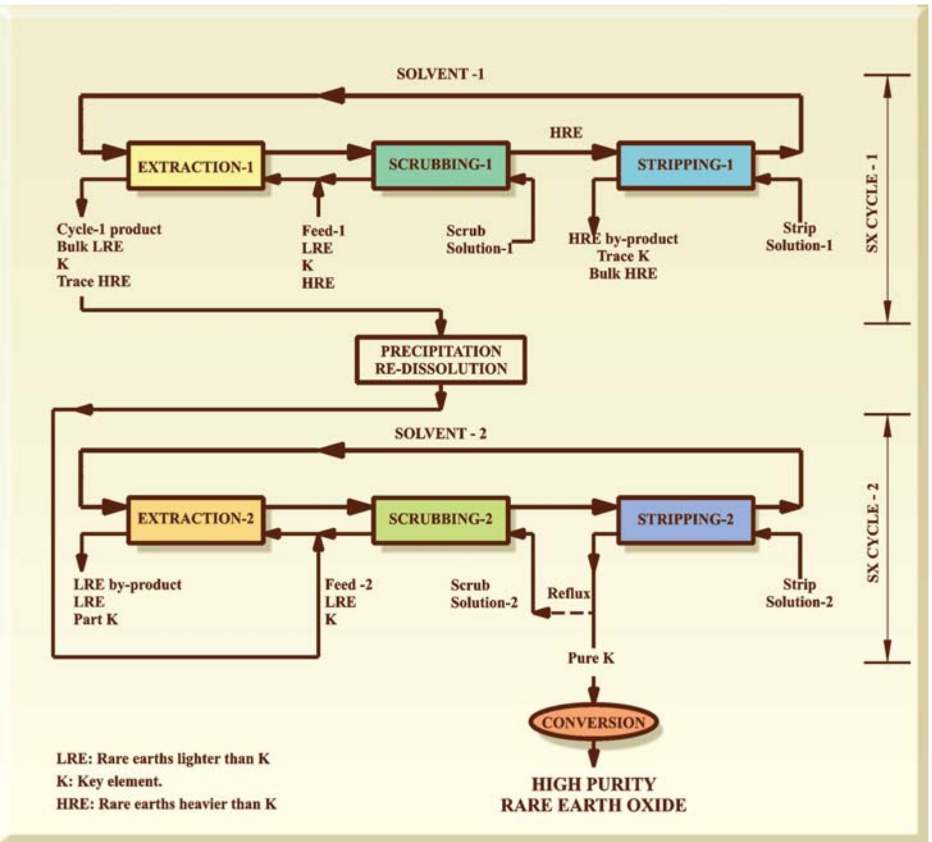


Fig. 2 : Generic Dual Solvent Extraction Separation Process

From a description of the generic process, it is evident that there are a large number of process variables that need to be optimized. These include :

1. Aqueous feed acidity (FFA)
2. Extract to aqueous phase ratio (OAET)
3. Number of stages in extraction (NEXT)
4. Scrubbing solution acidity (SCFA)
5. Scrub of organic phase ratio (OASCR)
6. Number of stages in scrubbing (NSCR)
7. Scrub concentration of metal ion (REOSCR)
8. Strip solution acidity (STFA)
9. Strip to organic phase ratio (OASTR)
10. Number of stages in stripping (NSTR)
11. Total rare earth oxide concentration in feed-1 (REOFD1)
12. Total rare earth oxide concentration in feed-2 (REOFD2)

The overall difficulty of separation, for obtaining a pure product from a given feed, can be indicated by a factor such as 'Decontamination Factor' (DF).

The DF values for the three separation systems of interest are shown in Table 2. High values of DF needed, combined with low values of separation factor (b) make the task of separation a complex one.

Table 2 : Decontamination factors for various REE separations

S.No.	Rare earth element	Typical Feed (%)	Product (%)	Decontamination Factor w.r.t K
1.	*Dy Separation System (DSS): key element K : Dy*			
	LRE	1	0.10	50
	Gd	4	0.15	133
	Tb	4	0.90	22
	Dy	19	95.00	
	Ho	3	0.40	38
	Y	65	3.05	107
	Er	4	0.40	50
2.	*Gd Separation System (GSS): key element K : Gd*			
	Sm	15.5	0.07	295
	Eu	1.5	0.005	400
	Gd	75	99.9	
	Tb	3.5	0.01	466
	Dy	2.5	0.01	333
	HRE	2	0.005	533
3.	*Tb Separation System (TSS): key element K : Tb*			
	Gd	3.3	0.055	87
	Tb	69	99.89	
	Dy	27.4	0.05	793
	Y	0.3	0.005	87

Note : Decontamination factor is the ratio of impurity to key element in feed, to the ratio of impurity to key element in product

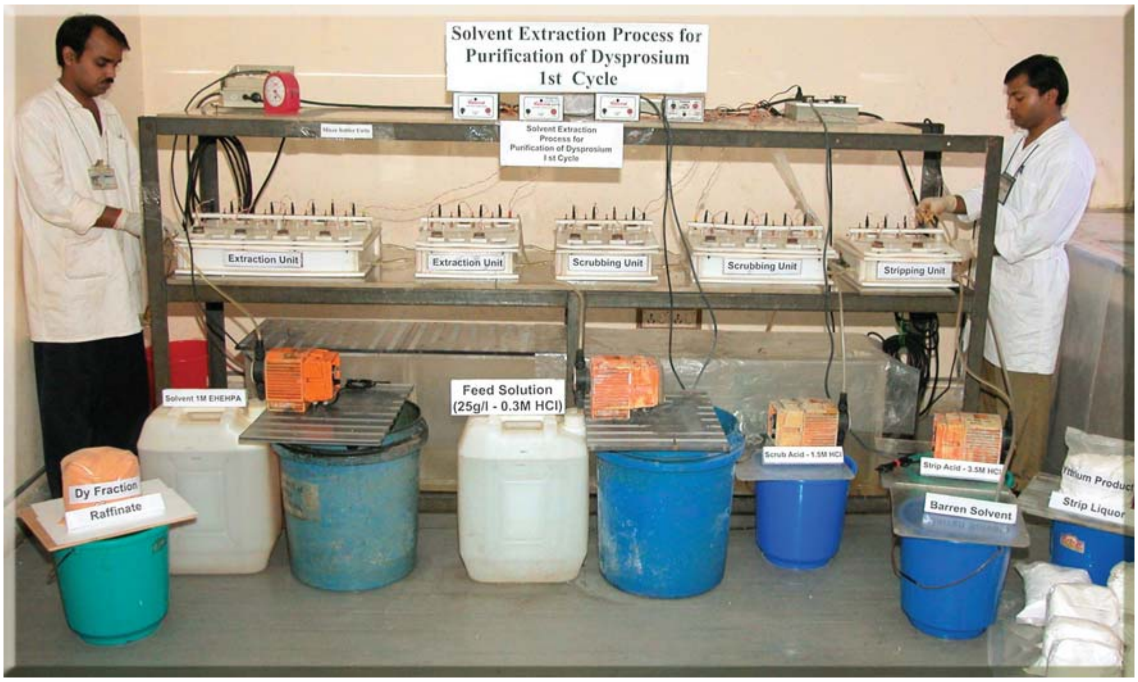


Fig. 3 : Mixer-settler cascade system for purification of Dysprosium cycle-1

Mathematical models are used to aid process simulation and optimization of complex REE separation processes. In particular, 'Artificial Neural Network' (ANN) based models have been tested and found superior to the conventional models, for predicting the equilibrium distribution ratio, as a function of the aqueous phase composition [4]. The ANN models combined with material balance models in a spread-sheet format suchas EXCEL have been successfully demonstrated, for application on an industrial scale. Based on process modelling, the operation of separation cascades has yielded high purity oxides of required purity, in bulk tonnage quantity.

Separation System Performance

Illustrative results are discussed herein. The first cycle of Dysprosium oxide was carried out using continuous flow mixer-settlers as shown in Fig. 3. The operation was carried out for well over four hundred hours. Performance results of a campaign are shown in Fig. 4. Purification achieved with regard to Yttrium, which is the primary objective of this cycle, is shown by stage-to-stage data plotted in Fig. 5. Kilogram quantity of Dy_2O_3 was thus produced, for the second cycle operation. Since there is considerable reduction in quantity from the first to

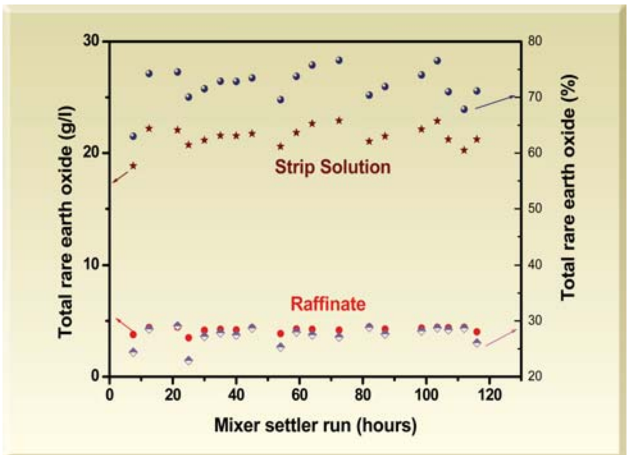


Fig. 4 : Operating data of a mixer-settler run for purification of Dysprosium cycle-1

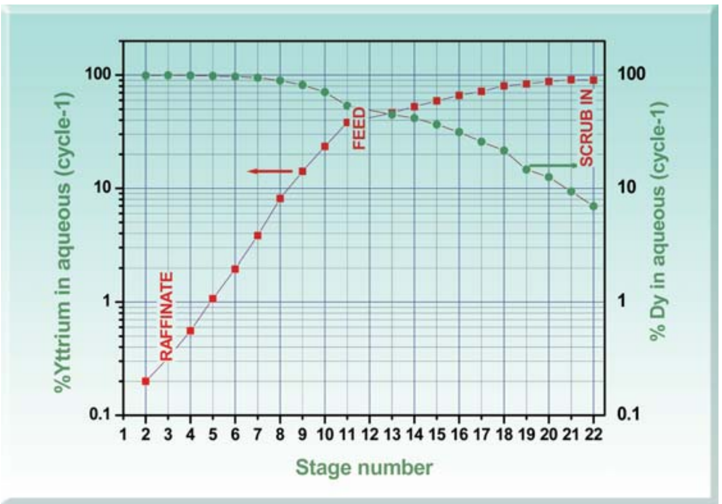


Fig. 5 : Purification of Dy_2O_3 w.r.t. Yttrium in cycle-1

the second cycle, the latter was carried out in special laboratory unit with motorized stirrers fitted into separatory funnels, as shown in Fig. 6. This operation involves discrete contacts [5]. Over 1600 contacts have been carried out to date. A photograph of the process product is shown in Fig. 7. Considerable data has been generated during this R&D work which is being analyzed, in terms of basic principles of separation science, including analysis based on 'mixed metal' isotherm concept, logarithmic McCabe-Thiele diagrams, key element analysis etc.

The effect of process parameters on performance of GSS has been analyzed in terms of 'factorial design of experiments'. In the first cycle, parameters of investigation included OAEXT, OASCR, SCRFA and NEXT+NSCR = NS, the total number of stages. With purity of product aqueous phase (raffinate–1) as response variable, it was found that OAEXT had maximum effect, SCRFA was the next in order followed by NS and OASCR. The recovery of Gadolinium was negatively impacted by all variables, except NS. In the second cycle, two more additional parameters were included: REOSCR and FFA. Results showed that the parameters pertaining to acidity of aqueous phase, namely SCRFA and FFA had a negative effect, while all others had a positive effect on the purity of the product in the organic phase. OAEXT was the next significant variable followed by REOSCR, SCRFA, FFA and NS. Effect of OASCR was not significant. Effect of acidity on recovery was likewise negative. It can be easily understood in terms of decrease in the distribution ratio of Gadolinium, with increasing hydrogen ion concentration, in accordance with the overall

Fig. 6 : Counter-current lab set-up with specialized motors for purification of Dysrosium in cycle-2

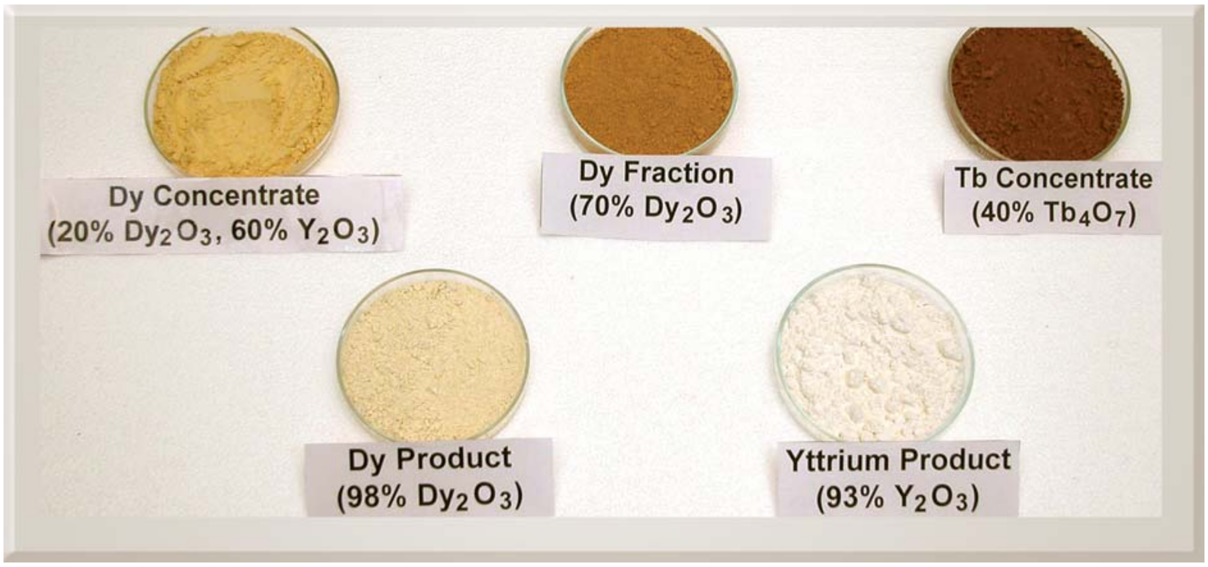


Fig. 7 : Process products of Dysprosium purification by solvent extraction

reaction shown earlier. The stage-to-stage data shown in Fig. 8 for the second cycle, confirms this. An important result from the study, was the significance of refluxing. The purity obtained was significantly higher than that obtained without it, bearing out the results of computer simulation. The pure oxide from the separation process was dissolved in high purity nitric acid, to obtain a solution of pH~3. The clear solution was evaporated till the temperature of the solution reached 130°C. Subsequent controlled cooling and stirring led to formation of fine crystals of Gadolinium hexa-hydrate. A sample of the product showed (μg/g) Na<l, Mg<1, Cl<6.5, Ce<1, Y=4, Nd<1, Sm<1, Eu=7, Dy<1 and Tb<1. The material, being hygroscopic, was packed in hermetically sealed containers and supplied to NPCIL for timely commissioning of their new Tarapur Power Station. A photograph of the product sample is shown in Fig. 9.

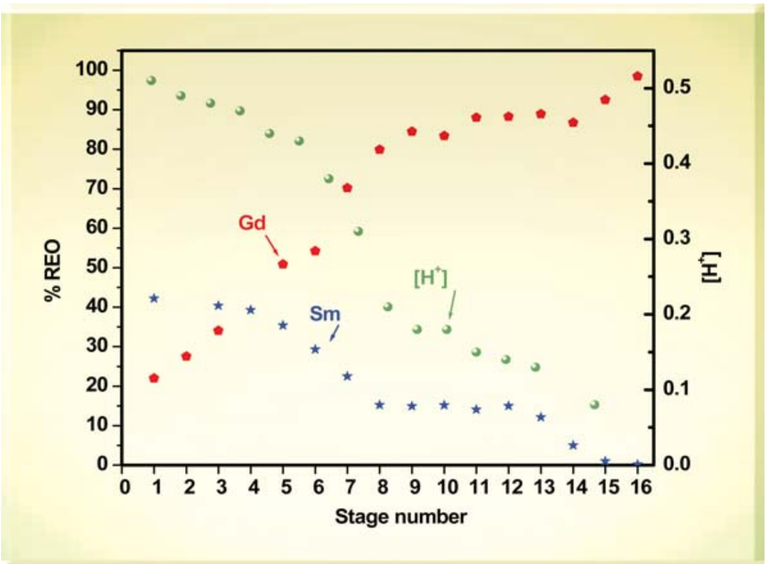


Fig. 8 : Stage-to-stage data for Gadolinium separation in cycle-2

Samples were also supplied to IGCAR, on their request for determination of solubility [6].

Separation of Terbium from a crude concentrate with the feed composition as shown in Table 2 was studied, using the same generic two-cycle process. Initial studies included the effect of total oxide in aqueous feed, to cycle-1 or REOFD1. It was found that an oxide concentration of 30g/1 was preferred over 40g/l. The experimental data showed, that the separation factors varied by ± 25%, when the aqueous phase acidity and composition changed.

Fig. 9 : Gadolinium nitrate crystals

Under optimum conditions, material of required purity was obtained, as shown in Fig. 10.

Allied Advances

Quality control of process performance requires sophisticated facilities for rare earths analysis. At REDS, a new ICP-AES JY Ultima-2 as shown in Fig. 11, was installed, recently commissioned and put to regular use. A comparison of samples analyzed with both the set-ups: an older instrument (Perkin Elmer 400 and the new JY Ultima-2) is shown in Fig. 12. It was found that trace element analysis is significantly more accurate and the separation process parameters are accordingly different [7-8]. The instrument has also been used for analysis of Uranium in the eluate stream from sea-water project in the < 1 ppm range [9].

Rare earths, co-extracted with Uranium by the patented D2EHPA-TBP and DNPPA-TOPO processes [10] need to be separated. Preliminary studies using radiotracers [11] have been followed by laboratory

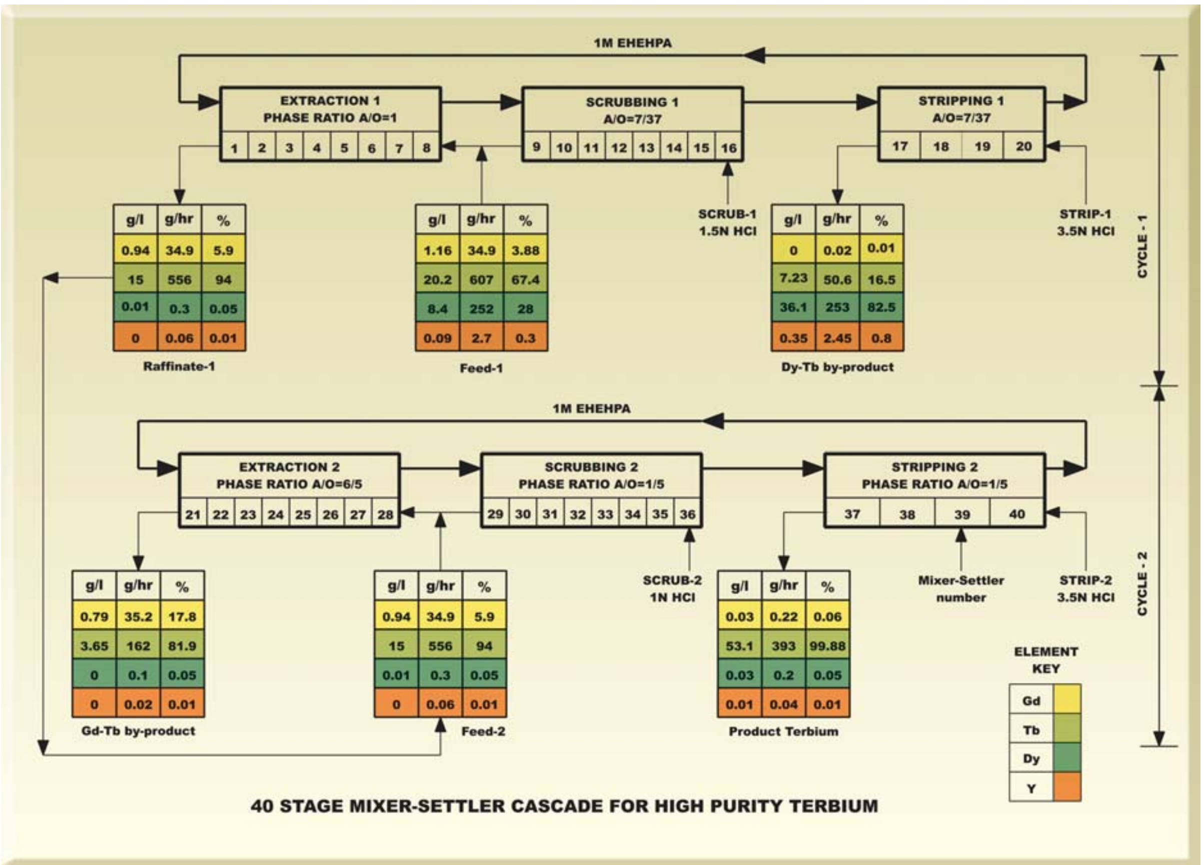


Fig. 10 : Material balance from 40 stage mixer-settler cascade for high purity Terbium

Fig. 11 : A high resolution ICP-AES installed at REDS

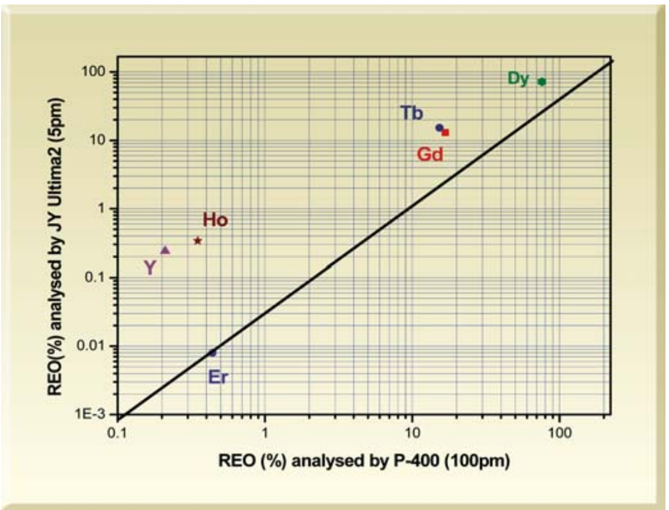


Fig. 12 : Comparative performance of JY Ultima-2 with P-400

scale studies with process solutions. This includes studies on kinetics of extraction [12]. It was found that while the distribution ratios of Uranium and Yttrium are similar, the rate of extraction of REE is higher by an order of magnitude. Further work is in progress as part of XI Plan project.

An important area of R&D where recent work has been carried out, pertains to entrained solvent separation. For acidic solutions, a multi-stage counter-current diluent washing was shown to be appropriate [13]. For alkaline solutions, absorption on activated carbon in columnar mode is needed [14]. The trace amount of solvents such as DNPPA can be accurately determined by methods such as HPLC [15]. Fig. 13 shows a photograph of a unit at REDS used for this work.

The high purity product rare earth oxides, have been used for phosphor synthesis [16,17] and evaluation

Fig.13 : High Performance Liquid Chromatography Unit

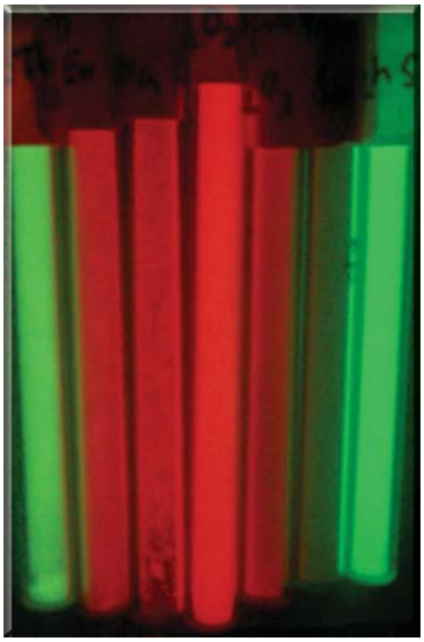


Fig.14 : Luminescence tubes glowing with tritium energy

as luminescent devices. An interesting strategic application is in the tritium filled tubes which glow from the radiation energy converted into light [18], Fig. 14. Another application involves addition of trace amounts of rare earths to inks used for legal documents. Such inks have a unique REE signature and are difficult to forge.

References

1. 'Dysprosium titanate as an absorber material for control rods,' V.D. Risovany, E.E. Varlashava, D.N. Suslov, *J. Nuclear Materials* 281 (2000) 84-89.

2. 'Neuton scattering lengths and cross-sections'; *V. F. Sears Neutron News*, Vol.3, No. 3 (1992) 29-37.

3. 'Simultaneous purification of dysprosium and terbium from dysprosium concentrate using 2-ethyl hexyl phosphonic acid mono-2-ethyl hexyl ester as an extractant,' S.L. Mishra, H. Singh and C.K. Gupta, *Hydrometallurgy,* 56 (2000) 33.

4. 'Artficial Neural Network Simulation of Rare Earths Solvent Extraction Equilibrium Data,' M.Anitha and H.Singh, *Desalination*, 232 (2008) 59-70.

5. 'Purification of Dy_2O_3 for AHWR : Operating data from a multistage cascade,' M. Anitha, M.K. Kotekar and H. Singh, Proceedings of INSAC 07, Hyderabad, Nov. 2007.

6. 'Gadolinium nitrate as soluble poison in dissolver system of PFBR fuel reprocessing plant (Private communication).

7. 'Recent developments in studies on separation process development for nuclear grade dysprosium oxide,' M. Anitha, M.K. Kotekar and H. Singh, Proceedings of DAE-BRNS Biennial Symposium on Emerging Trends in Separation Science and Technology, University of Delhi, Delhi, March 2008.

8. Ph.D Thesis titled 'Spectrochemical studies of nuclear materials,' M. K. Kotekar, Mumbai University, March 2003.

9. (Private communication).

10. 'Development of innovative process for the separation of high purity uranium from phosphoric acid,' H. Singh, *BARC News letter*, 284 , September 2007, 2-12.

11. 'Distribution behaviour of rare earth elements (REEs) during the recovery of uranium from phosphoric acid,' P.N. Pathak, A. Chatterjee, M. Anitha, H. Singh and V.K. Manchanda, Proceedings of NUCAR 2003, 299-300.

12. 'Uranium from phosphoric acid: Kinetics studies of the solvent extraction processes for separation based on statistical data analysis,' R. Vijayalakshmi, Kartikey K. Yadav and H. Singh, Proceedings SESTEC 2008, New Delhi, March 2008, 205-206.

13. 'Recovery of solvents from various aqueous streams obtained during uranium separation from phosphoric acid,' S.L. Mishra, R. Vijayalakshmi and H. Singh, Proceedings SESTEC 2006, Mumbai, Sep/Oct 2006, 144 - 145.

14. 'Studies on solubility of organo phosphorous reagents in aqueous streams of uranium from phosphoric acid,' R.Vijayalakshmi, J.S. Gill and H.Singh, BARC/2007/1/008.

15. 'Estimation of trace di-nonyl phenyl phosphoric acid from aqueous streams of uranium from phosphoric acid using HPLC,' J.S. Gill, R. Vijayalakshmi & H. Singh, Proceedings of INSAC 07, Hyderabad, Nov. 2007.

16. 'Spectral Properties and Emission Efficiencies of $GdVO_4$ Phosphors M. Anitha, P. Ramakrishnan,' A. Chatterjee, G. Alexander and H. Singh *J. Appl. Phys. A 74*, (2002) 153.

17. Ph.D. Thesis titled 'Preparation and characterization of rare earth based borates and related system,' M. Anitha, Mumbai University, Feb 2006.

18. 'Test report of rare earth based phopsphors supplied vis-a-vis Cu activated ZnS/CdS (Private communication).

MANUFACTURE OF INSTRUMENTED STEAM GENERATORS FOR FISBE PROJECT

C.P. Mahajan, K.N. Karn, J.J. Roy, S.B. Jawale and R.L. Suthar
Centre for Design and Manufacture

Introduction

CDM has successfully manufactured and delivered two Instrumented Steam Generators for the FIBSE (Facility for Integral System Behavior Experiments) project, based on the design and drawings, provided by the Reactor Engineering Division.

The FISBE facility simulates the Primary Heat Transport (PHT) system of a 235 MWe PHWR, viz., the Fuel Rod Cluster Simulators (FRCS), the Steam Generators (SGs), the Emergency Core Cooling System (ECCS), the Feed and the Bleed systems, along with their associated control systems. The facilty is to be used for conducting thermal hydraulic experiments, by simulating steady state, transient and accidental conditions in a PHWR.

The Steam Generator (SG), Fig.1, is one of the key components in the FISBE loop, which contributes a great deal, in simulating the behavior of the PHT system of the PHWR. It is a U-tube type, scale down model / replica of the SG of a PHWR. It's scaling down is only for the quantity of U-tubes, keeping the elevations of all components at the same level as that of the Steam Generator of a PHWR, thus making it a highly compact equipment with a high slenderness ratio. The temperature, pressure and flow conditions of the primary and secondary sides of the fluids are the same as that in a PHWR, to realistically simulate the heat transfer characteristics in the FISBE Steam Generator. A total number of 96 tapping points: 84 for temperature, 6 for pressure, 4 for flow rate and 2 for level and differential pressure measurements are provided.

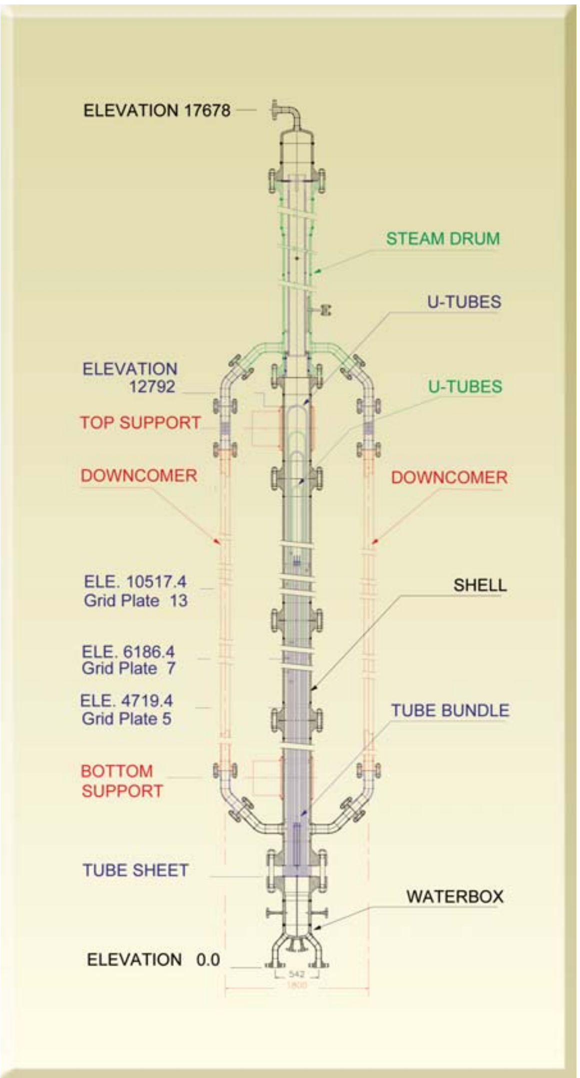


Fig. 1: Steam Generator

It's design conditions are as follows:

Primary (Tube) Side:
Pressure = 112.5 bar, Temp. = 315ºC
Secondary (Shell) Side:
Pressure = 70.0 bar, Temp. = 285ºC
(Designed as per ASME B & PV Code, Sec. VIII).

The material, diameter and pitch etc. of the U-tubes, as shown in Fig. 2, are also maintained the same as that in a PHWR. It has 46 U-tubes, out of which 4 are extensively instrumented for measurement of temperatures and pressures.It has 29 filler tubes, of various diameters, for maintaining the compactness of the SG of a PHWR.

In the SG of a PHWR, the down-comer is the annulus space between the SG shell and the down-comer shell. To overcome the difficulty in the measurement of flow rate in the restricted space, two external down-comers are provided in the FISBE Steam Generators. The down-comers are provided with expansion bellows, to take care of the differential thermal expansions of the components, up to 40 mm.

Manufacturing of the SG

Manufacturing of the highly compact, slender scaled-down models / replicas of high-temperature and high-pressure systems, was a challenging task for CDM, because of the exorbitant cost quoted for the manufacture of the same. The assembly and safe installation of the instrumented tubes, Fig. 2, without damaging the thermocouples, was a painstaking effort. Their manufacture required a lot of innovation and development of manufacturing processes. This work also involved incorporation of many design modifications in consultation with the designers. fThe successful fabrication of the Steam Generators involved development of the following manufacturing processes:

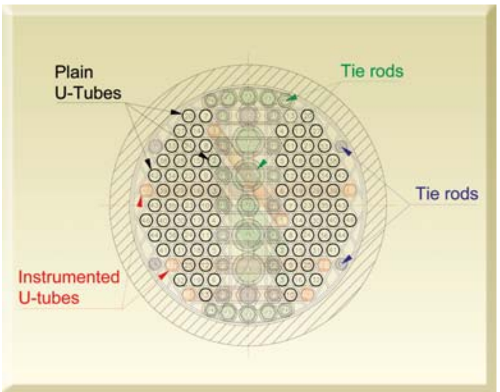


Fig. 2: Cross-section of Steam Generator

Welding process for cladding of C.S. Tube Sheet with Inconel-600

The welding process / WPS for a clad of 6 mm finished thickness Inconel-600, on the C.S. material, was qualified as per ASME B & PV Code, Section IX. The quality of the cladding on both tube sheets was certified by ultrasonic tests as per Section V and accepted as per Section VIII of the code. Successful cladding facilitated welding of Incoloy-800 U-tubes to C.S. tube sheet, as the direct welding of Incoloy-800 U-tubes to C.S. tube sheets was not feasible.

Manufacturing processes for fabrication of U-tubes

a) Forming of U-bend of Incoloy-800, 16 mm dia. / 1mm wall thick tubes on 1st leg to the desired radius at the same time controlling the ovality and wall thinning (within 10% of wall thickness).

b) Development of the welding process as per Section IX of the code, by automatic orbital pulse TIG welding method, for butt-welding of Incoloy-800 tubes of the 2^{nd} straight leg to the U-bend formed 1^{st} leg of U-tubes. All the U-Tubes thus fabricated as per the developed and approved manufacturing processes, were successfully hydro-tested at 320 bar pressure.

Manufacturing processes for fabrication, Welding and brazing of components on the Instrumented U-tubes

a) Development of welding processes as per Section IX of the code for welds of Incoloy-800, 16 mm dia. /1 mm wall thick, U-tubes to 10 mm dia. /0.8 mm wall thick SS-304L tubes for Impulse line tappings. Ref. Fig. 3.

b) Development of welding processes as per the Code for welding, by pulse TIG welding process, for welding the SS 304L Capillary Tube thermowells to the Incoloy-800, U-tubes, for introducing the thermocouples into the U–tubes. (Fig. 3).

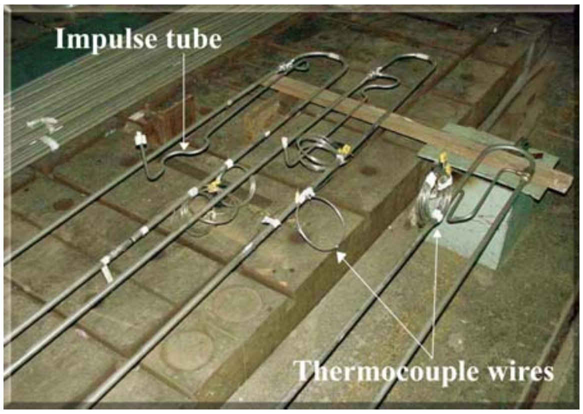


Fig. 3: U-tupes with tappings for Thermocouples and Impulse tube

c) Development of Brazing process as per the Code for joining SS sheathed Mica clad 1mm dia. thermocouples to SS-304L capillary tube thermowells (to introduce the thermocouples into the U–tubes) compatible for the given high pressure and high temperature service.

d) Development of brazing process as per the code for installation of the SS Sheathed Mica clad 1 mm dia. thermocouples in the grooves machined on Incoloyl-800 U-tubes and Fork Strips, compatible with the given high pressure and high temperature service.

e) Development of machining process for machining of miniature grooves on the 11.5 meter long Incoloy-800 U-tubes, at various locations and machining of fork strips for installation of the SS Sheathed Mica clad 1 mm diameter thermocouples.

All the instrumented U-tubes thus fabricated as per these processes were subjected to hydro test at 320 bar pressure and thermally cycled for 25 cycles, at 400º C.

Assembly of the Tube bundle

Assembly of the tube bundle was very critical, as only 0.5 mm clearance is available, for insertion of the11.5 meter long U-tubes in the openings in the grid plates. Grid plates, position and support the U-tubes of the tube bundle. All the 14 Grid

Fig. 4 : Tuble Bundle skeleton assembly-1st stage

Fig. 5: Tube Bundle skeleton assembly-2nd stage

plate assemblies are required to be aligned to the best possible extent to permit the assembly of very long U-tubes. (Figs. 4 & 5).

Insertion activities for the instrumented U-tubes, without damaging their thermocouples, into the tube-bundle skeleton / structure was more painstaking and required a lot of patience and skill. (Figs. 6 & 7). Needling out each of the thermo-couples, at various locations of the tube bundle without losing its identification, also required a lot of planning, care and skill.

Special handling fixtures (Fig. 8), were manufactured, for safe handling of the tube bundle in horizontal as well as in vertical condition (for welding of the tubes).

Fig. 6 : Insertion of U-tubes in the Tube Bundle

Fig. 7 : Tube Bundle final Assembly

Fig. 8 : Tube Bundle Assembly being lifted in fixture

Development of manufacturing processes for joining of Tube to Tube sheet

a) Process parameters were established, by mockup trials. The joining process was qualified by DP test, Helium leak test, Pull-out test and Micro-etching tests of the welds, to ascertain minimum leak path. Minimum leak path of 1 mm for tube-to-tube sheet joint could be achieved for all the tube joints.

b) Welding of tube-to-tube sheet was done by TIG welding process, in 1G position, by vertically holding the 11.5 meters long slender and delicate tube bundle assembly, on a special handling fixture. (Figs. 9 & 10).

c) Contact rolling (expansion) of tube inside the tube sheet was done, for full tube sheet thickness, by a three-stage over-lapped contact rolling method, as long rollers (equal to thickness of tube sheet) of the required diameter are not available commercially. Percentage of expansion was controlled, within 3 to 4% wall thinning, during the contact rolling operation.

Tube bundles of both the Steam Generators, were successfully manufactured and the tube side of the bundle assemblies were successfully hydro-tested at 320 bar pressure.

Fig. 9 : Vertical set up for Tube Bundle for welding of tube-to-tube sheet

Fig. 10 : Welding of Incoloy-800 Tubes to Tube sheet, in 1G position

Fabrication of the shells of the Steam Generator

Water box (bottom most part of the SG), four secondary / segmental shells, a separator shell and a steam drum (top most part of the SG) were fabricated from 350 NB / 400 NB, 120 Sch. C.S. pipes (Grade SA-106), and their flanges and dish ends from C.S. (Grade SA-105). Down-comers were fabricated from 200 NB, 120 Sch. C.S. Pipes (Grade SA-106), and their flanges and elbows from C.S. (Grade SA-105).

Nozzles for inlet and outlet connections were of sizes 65 NB. Special ½" NPT threadolets, with their 45 degree angular position on the shells, were machined and welded, for extraction of the thermo-couples, attached to the instrumented U-tubes of the tube bundle. Nozzles of size 20 NB, at various locations, were welded for (i) extraction of the thermo-couples, (ii) for impulse tube tappings and (iiii) for fluid pressure and fluid level measurements.

All welding work was done by qualified welders and in accordance with approved welding procedure/WPS as per Section IX, inspected as per Section V and accepted as per Section VIII of the ASME B&PV Code. The shell assemblies of both Steam Generators were successfully hydro-tested at 120 bar pressure.

Final assembly of the individual shells

The four segmental shells were assembled over the 11.5 meter long tube bundle, one by one and with safe extraction of thermocouples without damaging them through their respective extraction ports on shells. It is the most difficult part of the job, as only a 3 mm radial clearance between tube bundle OD and shell ID is available. Also since vertical space is not available, the assembly of these Shells on the 11.5 meter long tube bundle has to be done in horizontal position by inserting the shells, one by one, on to the tube bundle assembly, which is supported at various points. (Fig.11). Supports for the tube bundle are to be removed and thermocouples are to be extracted through the outlet threadolet nozzles progressively, while the shells, held by the crane, are slowly being moved in to their positions on the bundle.

Utmost care is needed to avoid entanglement and breakages of the 84 (SG1)/36 (SG2) thermocouples, while the segmental shells are being moved over the tube bundle. All the four secondary shells were successfully assembled, with the damage limited to only two thermocouples. All the thermocouples were extracted through ¼" NPT threadolet nozzles welded on the shell and sealed using transducer glands.

The flanges of shells were bolted together, using hydraulic torque wrench for the optimum torque, with the spiral wound metallic reinforced asbestos sealing gaskets in place.

The two completed Steam Generator assemblies (Fig.12), have been successfully subjected to hydro-tests as follows:

Fig. 11 : One-by-one assembly of the shells on the 11.5 meter long Tube-Bundle

Fig. 12 : Final assembly of Steam Generator

Tube side pressure: 320 bar, at room temp.
Shell side pressure: 115 bar, at room temp.

Safety during transportation of the Steam Generators

For protecting the vulnerable (spiral wound metal) gaskets at the flanged bolted joints during transportation, special protective close fitting spacers / packings were machined and fixed on all the flanged joints. This special care is needed as the gaskets once assembled are non–replaceable during the life of the Steam Generator.

Also special handling fixture and supporting brackets were fabricated for lifting, handling transportation and storage at the Hall 7 site.

Fig. 13 : Transportation of Steam Generator

Steam Generators were delivered in three parts; (i) tube bundle with its Shells and (ii) the down-comer sub-assemblies, (Fig. 13), in a 12 meter long tractor-trailer and (iii) steam drum and separator shell sub-Assembly separately in a truck. All sub-assemblies of Steam Generators were delivered by CDM at the Hall 7 site of RED, BARC on 15th May, 2008. FRCSs were delivered earlier. All this equipment will now be integrated by RED, BARC in the FISBE facility.

DAE-BRNS NATIONAL SYMPOSIUM AND WORKSHOP ON THERMAL ANALYSIS (THERMANS-2008) : A REPORT

The Sixteenth DAE-BRNS National Symposium and Workshop on Thermal Analysis (THERMANS 2008) was held at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, during February 4-8, 2008.

There was an overwhelming response to the symposium and workshop. In all, there were 220 registered participants who were from academic and research institutions, with a significant percentage of student and research scholar participants.

Dr. Vasudeva Rao, Director, Chemistry Group, IGCAR, welcomed the participants to the symposium and also highlighted the activities of the Chemistry Group of IGCAR, in the field of thermal analysis. Dr. Shyamala Bharadwaj, Convener of the Symposium gave an account of how the Indian Thermal Analysis Society has been arranging the biennial symposia, without a break, since 1977. She pointed out that this was possible because of the financial support from BRNS and the enthusiasm of local organizers like IGCAR, various universities and other national laboratories.

Inaugural function of THERMANS-2008. From Left to right: Dr. V. Venugopal (Director, Radiochemistry and Isotope Group, BARC), Dr. Salil Varma (Secretary, THERMANS-2008),Dr. Vasudeva Rao (Director, Chemistry Group, IGCAR), Dr. Baldev Raj (Director, IGCAR), Dr. Shyamala Bharadwaj (Convener, THERMANS-2008) and Dr. T. G. Srinivasan (Chairman, LOC, THERMANS-2008)

The symposium was inaugurated by Dr. Baldev Raj, Director, IGCAR and Dr. V. Venugopal, President, Indian Thermal Analysis Society and Director, Radiochemistry and Isotope Group, BARC, presided over the function. Dr. Venugopal in his presidential address, cited the active role played by thermal analysis in the development of unique mixed carbide fuels and its contribution to the out-of-pile studies on Mark I carbide fuel, fabricated by BARC scientists, for FBTR. He also pointed out that thermal analysis will have a greater role to play in the coming years as the Department of Atomic Energy is taking on the challenging tasks pertaining to PFBR, AHWR, CHTR fuel development, materials problems for ADS, SOFC, thermo-chemical water splitting for production of hydrogen using nuclear heat etc.

In his thought-provoking inaugural address, Dr. Baldev Raj emphasized the need for publishing good quality text books in Thermal Analysis, for improving the standard of teaching the subject in academic institutions. He also pointed out that the best way to enthuse young researchers was to give challenging assignments to them. The proceedings of the symposium and workshop which also carried invited talks by experts, were released by Dr. Baldev Raj and were distributed to the delegates. A souvenir was brought out by the Indian Thermal Analysis Society on this occasion and was released by Dr. Vasudeva Rao. For the first time in this series of symposia, compact discs containing both the symposium proceedings and workshop lectures, were brought out. Dr. Venugopal released these CDs and these were also distributed to the delegates.

Dr. Salil Varma, Secretary, National Organizing Committee, announced the awards instituted by the Indian Thermal Analysis Society. The awards were presented by Dr. Baldev Raj, Dr. V. Venugopal and the sponsors of the awards. The NETZSCH – ITAS Award 2008 for senior scientist was conferred on Dr. Arun Pratap of M. S. University, Baroda. The TA Instruments – ITAS Young Scientist Award 2008 was shared by Dr. S. C. Parida, Product Development Division, BARC

Dr. Baldev Raj, Director, Indira Gandhi Centre for Atomic Research, releasing the symposium proceedings. He is flanked by Dr. Vasudeva Rao and Dr. V. Venugopal on left and Dr. T. G. Srinivasan and Dr. Shyamala Bharadwaj on right.

and Dr. (Ms.) M. R. Pai, Chemistry Division, BARC. Dr. M.D. Karkhanavala Memorial Essay Contest 2008 was won by Ms. Aarti Bhat, National Institute of Technology, Suratkal. Dr. Gurdip Singh Award for Best Thesis in Thermal Analysis 2008 was given to Dr. Y. S. Malghe, Institute of Science, Mumbai.

There were 10 technical sessions and 12 invited lectures. Five of the invited lectures were by experts from abroad. More than 120 research papers were presented at the symposium in both oral and poster sessions.

ITAS awarded cash and merit certificates for best papers presented in both oral and poster sessions. In order to encourage young researchers in the field of thermal analysis, the oral presentations were restricted to research scholars below the age of 30.

The THERMANS-2008 workshop was inaugurated by Dr. S.R. Dharwadkar, University of Mumbai, a doyen of thermodynamics in India. In the workshop, there were 45 research scholars and student participants. There were 11 invited lectures by eminent scientists on different aspects of thermal analysis. Various experimental techniques such as transpiration method, galvanic cell method, calorimetry etc. were dealt with.

Prof. Pelton, one of the developers of the FACTSAGE software, conducted a two-day, hands-on workshop on the software. This workshop was conducted as a satellite workshop to the main THERMANS-2008. 38 participants from DAE and other academic and research institutes attended the workshop and learned the techniques for using the software for various applications, including phase diagram computations.

ANNOUNCEMENT

Forthcoming Symposium

(International Symposium on Materials Chemistry 2008)

(ISMS-2008)

The Chemistry Divn., BARC, is organizing the 2nd International Symposium on Materials Chemistry and which is sponsored by DAE BRNS. It will be held at BARC, Trombay, Mumbai, from Dec. 2-6, 2008. The symposium will throw light on contemporary research in the field of Materials Chemistry. Abstracts on the following topics are to be submitted on or before 14th Aug. 2008, either by e-mail (Dr. V.K. Jain, Secretary, ISMC 2008 at ismc-08@barc.gov.in) or as hard copies in duplicate.

1. Nuclear materials and Fuel cells materials 2. Materials for hydrogen generation and storage 3. High purity materials 4. Thin films, Nanomaterials and clusters 5. Magnetic materials, Carbon-based materials 6. Materials for catalysis, 7. Soft condensed materials and surface chemistry, 8. Chemical sensors and Computational research in materials chemistry.

Important Dates

Pre-registration & submission of abstracts	- Aug. 14, 2008
Acceptance of papers	- Sep. 15, 2008
Payment of registration fees	- Sep. 30, 2008

For further details please contact

Dr. D. Das
Convener, ISMC 2008
Chemistry Divn., BARC, Trombay,
Mumbai-400 085, India
Tel.: +91-22-25595102 (O) 25578980 (R)
Fax : +91-22-25505331; 25519613
E-mail : dasd@barc.gov.in

Dr. V. K. Jain
Secretary, ISMC-2008
Chemistry Divn., BARC, Trombay,
Mumbai- 400 085, India
Tel : +91-22-25595095 (O) 2557 0021 (R)
Fax : +91-22-2550 5331; 25519613
E-mail : jainvk@barc.gov.in

DAE-BRNS SYMPOSIUM ON EMERGING TRENDS IN SEPARATION SCIENCE AND TECHNOLOGY (SESTEC-2008): A REPORT

Dr. S. Banerjee, Director, BARC, delivering the inaugural address

The DAE-BRNS Symposium on Emerging Trends in Separation Science and Technology (SESTEC-2008) was held at the Conference Centre, University of Delhi, Delhi during March 12-14, 2008. In the inauguration session, Prof. V.S. Parmar, Head, Department of Chemistry, University of Delhi welcomed the delegates and invitees (approx. 300) from various academic/ research institutes including DAE, CSIR and IITs. Dr. Banerjee, Director, BARC in his inaugural address, mentioned that separation science and technology plays a vital role in meeting the challenges related to our indigenous twin programme on nuclear power and the application of radioisotopes for societal benefits. He described the formation of underground uranium deposits. He emphasized the importance of the development of new green solvents /technology in the context of global warming. Prof. Pental in his presidential address emphasized the role of separation science and technology in all disciplines of modern day science. He suggested that universities should be supported in a big way, for conducting basic research. Dr. V. Venugopal, Director, RC&I Group, BARC in his introductory remarks, highlighted the role of separation science in nuclear industry. Dr. V.K. Manchanda, Convener, SESTEC-2008 and Head, Radiochemistry Division, BARC introduced the theme of the Symposium and acknowledged the overwhelming response received from delegates within the country as well as the response from overseas speakers.

Seventy five delegates from BARC, participated in the Symposium. In all, there were twenty nine invited lectures and one hundred thirty seven contributory papers, presented as posters. All the posters were displayed throughout the period of the Symposium. Fourteen eminent overseas scientists from prestigious academic institutions, participated in SESTEC-2008.

At the inaugural function from left to right are: Dr. V.Venugopal (Director, RC&I Group, BARC), Dr. S. Banerjee (Director, BARC), Prof. Deepak Pental (Vice Chancellor, University of Delhi), Dr. V.K. Manchanda (Head, Radiochemistry Division, BARC & Convener, SESTEC-2008) and Prof. R.C. Rastogi (Dept. of Chemistry, Delhi University & Secretary, LOC)

Apart from solvent extraction and ion exchange, a wide range of topics related to separation science and technology were covered. It included modeling, solid phase extraction, membrane-based separations and pyrochemical reprocessing. Special technical sessions were arranged on "*Nuclear Applications*", "*Membrane Separations*" and "*Chromatographic Separations*". A special feature of SESTEC-2008 was the introduction of a new technical session on "*Biochemical Separations*". On March 12, 2008, a special INASAT special seminar was arranged, on "*Indigenous Chromatographic Equipment*". Mr. S. Thakur, Executive Director, NPCIL delivered a special public lecture on "*Nuclear Power Scenario in India*" on March 13, 2008.

The concluding session of SESTEC-2008 was chaired by Dr. P. R. Vasudeva Rao, Director, Chemistry, Metallurgy and Materials Group, IGCAR, Kalpakkam. Prizes were awarded for best paper presentations, which were sponsored by INASAT (co-organizer of SESTEC-2008). Dr. A.K. Kohli, Chief Executive, BRIT, was the chief guest. He delivered a keynote address on "*Applications of Radioisotopes for Societal Benefits*". A feed back session was arranged to seek suggestions for future programmes. Dr. P.R. Vasudeva Rao suggested that young researchers could make use of opportunities such as participation in SESTEC-2008, to interact with experts and learn presentation skills. Dr. V.K. Manchanda, Convener, SESTEC-2008 highlighted the important role played by separation scientists and technologists in nuclear industry and new challenges to be met in years to come. It was suggested that participation of engineers / technologists should be encouraged, to turn scientific research into a technological reality. Dr. P.N. Pathak, Secretary, SESTEC-2008 thanked BRNS, the invited speakers, the participants, members of different committees for their help and support in the organization of the symposium.

DAE-BRNS BASIC SCIENCES SCHOOL ON CONDENSED MATTER INTERFACE WITH CHEMISTRY AND BIOLOGY (CMICB–08): HIGHLIGHTS

The DAE-BRNS Basic Sciences School on Condensed Matter Interface with Chemistry and Biology (CMiCB–08), was held during March 3-14, 2008, at the Homi Bhabha Centre for Science Education (HBCSE), Mumbai. The School was organized by BARC, Mumbai in association with HBNI, HBCSE and MRSI (Mumbai Chapter). The aim of this School was to equip young researchers working in the area of Condensed Matter Physics with sufficient knowledge about topics in Chemistry and Biology, that interface with the soft matter aspects.

The School was inaugurated by Dr. S. Banerjee, Director, BARC. Dr. J. V. Yakhmi, Associate Director, Physics Group (S), BARC and HEAD, TP&PED, BARC, delivered the welcome address as the convener of the School. Dr. V. C. Sahni, Director, Physics Group, BARC & Director, Raja Ramanna Centre for Advanced Technology, Indore, gave the presidential address. The introductory remarks were made by Prof. Arvind Kumar, Center Director, HBCSE. The vote of thanks was proposed by Dr. S. M. Yusuf, SSPD, BARC as the Secretary of the School.

The total number of registered participants was 54. This included 42 Indian (non BARC) participants from 13 different states, 11 BARC participants and one overseas participant. There was equal participation from the national laboratories and the universities. Out of a total of 54 participants, two participants were Doctorates and the remaining participants were pursuing their Ph.Ds.

The regular lectures covering the interdisciplinary areas of Physics, Chemistry and Biology were delivered by 5 overseas and 9 Indian speakers with several years of research experience in their respective fields. 44 regular lectures were delivered during a period of

Inaugural function: Sitting on the dais from left: Dr. J. V. Yakhmi, Associate Director, Physics Group, BARC and Head, TP&PED, BARC, also Convener, CMiCB-08; Dr. V. C. Sahni, Director, Physics Group, BARC & Director, Raja Ramanna Centre for Advanced Technology, Indore; Dr. S. Banerjee, Director, BARC; Prof. Arvind Kumar, Center Director, HBCSE, Mumbai; Dr. S. M. Yusuf (Secretary, CMiCB-08), SSPD, BARC.

12 days. Prof. J. P. Parneix from France, Dr. Eva Bystrenovà from Italy, and Prof. V. Ramgopal Rao of IIT Mumbai, covered a broad area of Organic electronic devices / Nanoelectronics. Excellent lectures on carbon nanotubes were delivered by Prof. G. Baskaran, IMSc, Chennai and Prof. Kari Rissanen, Finland. Dr. Ch. Mohan Rao from CCMB, Hyderabad, Prof. K. N. Ganesh from IISER, Pune and Dr. S. K. Apte from BARC delivered lectures on DNA / Protein. Some important lectures on biomedical applications and biosensors were given by Prof. D. Bahadur, IIT, Mumbai, Dr. P. K. Gupta, RRCAT, Indore, Prof. K. N. Ganesh, IISER, Pune and Prof. V. Ramgopal Rao, IIT, Mumbai. The lectures on molecular magnets, chirality and multiferroics were delivered by Prof. K. Inoue, Japan. Another renowned Japanese scientist, Prof. M. Tokumoto delivered lectures on molecular metals. Dr. P. A. Hassan from BARC taught about surfactants and polymers, while Dr. V. K. Aswal, BARC talked about the study of micelles using SANS and SAXS. There were two special interactive sessions for the participants where they could briefly present their research work. A visit to various facilities in BARC was also arranged for the participants.

There were 5 special lectures. These were delivered by Prof. G. Baskaran (Superconductivity), Dr. V. Venugopal, BARC (Radiochemistry and Nuclear fuels), Prof. K. P. N. Murthy, Hyderabad Central University (Thermodynamics), Dr. S. K. Apte, BARC (Genetic Engineering) and Dr. J. V. Yakhmi, BARC (Condensed Matter Interface with Chemistry and Biology).

The School was a grand success with participation from abroad and from all over India. The interaction and exposure in this School gave an excellent opportunity to all the participants to pursue future research work in the interdisciplinary area of science.

Certificates were awarded to all the participants for successfully completing the course work. The concluding session started with a brief Power Point presentation by Dr. S. M. Yusuf, Secretary, CMiCB-08 on some important statistics of the participants and a brief summary of the lectures delivered during this School. He thanked all the speakers for delivering wonderful lectures and congratulated the participants for successfully completing the course-work. In the concluding remarks, Dr. J. V. Yakhmi, Convener, CMiCB-08 gave a beautiful insight of the past and present scenario of science in India. Dr. Yakhmi also appreciated the well co-ordinated team-work of all the volunteers.

Participants of CMiCB-08 with the dignitaries on the inaugural day of the School

भा.प.अ. केंद्र के वैज्ञानिकों को सम्मान

BARC SCIENTISTS HONOURED

वाइ.वी.नन्चराइया, ई.विन्नीथा, एवं वी.पी.वेणुगोपालन द्वारा लिखित "एप्लिकेशन ऑफ कॉनफोकल लेज़र स्केनिंग माइक्रोस्कोपी इन मेरीन माइक्रोॲलगल इकाटॉक्सिसिटी स्टडीज़" नामक शोध-पत्र को फरवरी 5-7, 2008, के दौरान गोआ में नैशनल इन्सटिट्यूट ऑफ ओशनोग्राफी में आयोजित "इन्टरनैशनल कॉनफ्रेन्स ऑन बायोफाउलिंग एन्ड बेलेस्ट वाटर मेनेजमेंट" सम्मेलन में सर्वश्रेष्ठ शोध-पत्र पुरस्कार से सम्मानित किया गया।

A paper entitled "Application of confocal laser scanning microscopy in marine microalgal ecotoxicity studies" authored by Y.V. Nancharaiah, E. Vinnitha and V. P. Venugopalan was bestowed with the best paper award at the "International Conference on Biofouling and Ballast Water Management" held at the National Institute of Oceanography, Goa, during 5-7 February 2008.


Mr. Y. V. Nancharaiah

वाइ.वी.नन्चराइया ने आन्ध्रा विश्वविद्यालय, विशाखापटनम से जीव रसायन में एमएससी की डिग्री प्राप्त की तथा भाभा परमाणु अनुसंधान प्रशिक्षण विद्यालय के 38वें बैच द्वारा (जीव विज्ञान एवं विकिरणजीव धारा) पानी एवं भाप रसायन प्रभाग (डबल्यूएससीडी) रसायन वर्ग, भाभा परमाणु अनुसंधान केंद्र में सदस्यता ली। इनकी रुचि के क्षेत्र में माइक्रोबियल बायोफिल्म करेक्टरैज़ेशन एवं कंट्रोल इन कूलिंग वाटर सिस्टमज़, बायोफिल्म बेस्ड बायोरेमिडियेशन यूज़िंग ग्रेन्युलर बयोफिल्मज़ रियक्टर टेक्नालोजी, एप्लिकेशन ऑफ कॉनफोकल लेज़र स्केनिंग माइक्रोस्कोपी फॉर इन सिटू मोनिटरिंग ऑफ एनविरोनमेन्टल इफेक्टस ऑफ कंटेमिनन्टस भी शामिल हैं।

Mr. Y.V. Nancharaiah completed his M. Sc. in Biochemistry from Andhra University, Vishakhapatnam and joined the Water and Steam Chemistry Division (WSCD), Chemistry Group, BARC through the 38th batch of BARC Training School (Biology and Radiobiology stream). His fields of interest include 1) microbial biofilm characterization and control in cooling water systems 2) biofilm based bioremediation using granular biofilms reactor technology and 3) application of confocal laser scanning microscopy for *in situ* monitoring of environmental effects of contaminants.


Ms. Ebenezer Vinnitha

इबेनेज़र विन्नीथा, एईआरबी की शोध-स्नातक, डबल्यूएससीडी में कार्यरत हैं। इन्होंने मनोनमेनियन सुंदरानार विश्वविद्यालय, तामिल नाडू से एनविरोनमेंटल साइन्स में एमएससी की डिग्री प्राप्त की। इनकी रुचि के क्षेत्र में इम्पेक्ट ऑफ पॉवर प्लांट एन्ट्रेनमेन्ट ऑन मेरीन फाइटोप्लंकटॉन भी शामिल है।

Ms. Ebenezer Vinnitha is an AERB research scholar working at WSCD. She did her M. Sc. in Environmental Sciences from Manonmanian Sundaranar University, Tamil Nadu. Her research interest includes impact of power plant entrainment on marine phytoplankton.


Dr. V.P. Venugopalan

डॉ. वी.पी.वेनुगोपालन ने नैशनल इनस्टिट्यूट ऑफ ओशनोग्राफी से पी.एच.डी. के पश्चात् वर्ष 1989 में डबल्यूएससीडी में सदस्यता ली तथा इस समय आप बायोफाउलिंग एवं बायोफिल्म प्रोसेसिज़ डबल्यूएससीडी विभाग के अध्यक्ष हैं। इनकी रुचि के क्षेत्र में बायोफाउलिंग, बायोफिल्मज़ एन्ड थर्मल इकोलॉजी भी शामिल है।

Dr. V. P. Venugopalan joined WSCD in 1989, after completing his Ph.D. from National Institute of Oceanography and is currently heading the Biofouling and Biofilm Processes Section of WSCD. His research interests are biofilms, biofouling and thermal ecology.


Dr. S.D. Sharma

डॉ. सुनील दत्त शर्मा विकिरण चिकित्सात्मक भौतिकी एवं सलाहकार प्रभाग (आरपी एन्ड एडी), भाभा परमाणु अनुसंधान केंद्र, मुंबई, को अगस्त 12, 2007 में कांचीपुरम, तामिलनाडु में डॉ. सिरिल ए. जयाचंद्रन एंडोमेंट ओरेशन अवार्ड ऑफ एसोसियेशन ऑफ मेडिकल फिज़िसिस्टस ऑफ इन्डिया-तामिलनाडू एन्ड पुडुच्चेरी चेप्टर पुरस्कार प्राप्त हुआ। डॉ. शर्मा को यह पुरस्कार चिकित्सा-संबंधी भौतिक शिक्षा एवं अनुसंधान के क्षेत्र में समर्पित सेवा तथा विज्ञान एवं मानवता के प्रति उनकी व्यक्तिगत उपलब्धियों को मान्यता देने हेतु प्रदान किया गया।

डॉ. शर्मा ने एम.एससी. (भौतिक-विज्ञान), मगध विश्वविद्यालय, बोध-गया बिहार से, एवं विकिरण चिकित्सा भौतिक-विज्ञान में स्नातकोत्तर तथा पीएचडी मुंबई विश्वविद्यालय से पूर्ण किया। इन्होंने वर्ष 1996 जनवरी में आरपी एन्ड एडी की सदस्यता ली। आप पिछले 15 वर्षों से चिकित्सा-संबंधी भौतिकी क्षेत्र में कार्यरत हैं। इस समय आप आरपी एन्ड एडी विभाग के विकिरण भौतिकी एवं उपकरण वर्ग के प्रमुख हैं। डॉ. शर्मा इस समय टेलीकोबाल्ट यंत्रों के उपयोग से मध्यम मूल्य मल्टिलीफ कोलिमेटर एवं स्टीरियोटेक्टिक रेडियोसजरी/रेडियोथेरेपी उपकरणों के विकास में, मध्यम मूल्य चिकित्सा संबंधी भौतिकी यंत्र एवं गुणवत्ता आश्वासन की मात्रामिति/रेडियोथेरेपी का परीक्षण, एवं व्यासमापन, अनुसंधान तथा प्रशिक्षण के उपयोग हेतु प्रगतिशील रेडियोलाजिक्ल भौतिक कार्यशाला की स्थापना के विकास में व्यस्त हैं। आप चिकित्सा-संबंधी भौतिक शिक्षा के संकाय एवं परीक्षक तथा आरपी एन्ड एडी तथा देश के अन्य विश्वविद्यालयों में प्रशिक्षण की हैसियत से काम कर रहे हैं। भाभा परमाणु अनुसंधान केंद्र के प्रशिक्षण विद्यालय में (रेडियोलॉजिकल सेफ्टी इंजीनियरिंग) में आप संकाय एवं पाठ्यक्रम समन्वयक का काम भी संभाल रहे हैं।

Dr. Sunil Dutt Sharma of Radiological Physics & Advisory Division (RP&AD), Bhabha Atomic Research Centre, Mumbai received the Dr. Cyril A. Jayachandran Endowment Oration Award of Association of Medical Physicists of India - Tamilnadu & Puduchhery Chapter on August 12, 2007 at Kancheepuram, Tamilnadu. This award was conferred on Dr. S. D. Sharma for his dedicated service in the field of Medical Physics Education and Research and in recognition of his individual achievements and contribution to science and humanity.

Dr. S. D. Sharma completed his M. Sc. (Physics) from Magadh University, Bodh-Gaya, Bihar and Post Graduate Diploma in Radiological Physics (Dip. R. P.) and Ph. D. from University of Mumbai, Mumbai. He joined RP&AD in January 1996. He is working in the field of Medical Physics for the last fifteen years. He is leading the Radiotherapy Physics and Instrumentation Group of Medical Physics & Advisory Section, RP&AD. Dr. Sharma is currently involved in the development of low cost multileaf collimator and stereotactic radiosurgery/ radiotherapy devices for use with telecobalt machines; development of low cost Medical Physics instruments and phantoms for dosimetry and quality assurance / audit in radiotherapy; and establishment of an advanced radiological physics laboratory for use in calibration, research and training. He serves as faculty and examiner on Medical Physics education and training at RP&AD as well as at different universities in the country. He also serves as the faculty for the BARC Training School as well as course coordinator (Radiological Safety Engineering).

श्री. एस. सक्सेना एवं श्री. बी. बी. मिश्रा, खाद्य प्रौद्योगिकी प्रभाग ने 31 दिसंबर 2007 से जनवरी 2008 के दौरान आइआइटी खडकपुर में आयोजित 19 वीं इंडियन कन्वेंशन ऑफ फुड सांइटिस्टस एन्ड टेक्नॉलोजिस्टस् ऑन हेल्थ फुड्स (आइसीएफओएसटी 2007) सभा में "शल्फ स्टेबल इंटरमिडिऐट मोइस्चर पाइनएपल स्लाइसिज़ यूज़िन्ग हर्डल टेक्नालोजी" नामक शोध की प्रस्तुती पर सर्वश्रेष्ठ पुरस्कार प्राप्त किया।

Mr. S. Saxena and Mr. B.B. Mishra from the Food Technology Divn., won the Best Poster Award for their paper " Shelf Stable Intermediate Moisture Pineapple Slices Using Hurdle Technology" presented at the 19th Indian Convention of Food Scientists and Technologists on Health Foods (ICFOST 2007) held at IIIT, Kharagpur, from 31st Dec. 2007 to 2nd Jan 2008.


Mr. S. Saxena

श्री. एस. सक्सेना ने वर्ष 2003 में मदुराई कामराज विश्वविद्यालय, में एमएससी (बायोटेक्नालोजी) पूरा किया। इन्होंने वर्ष 2004 में (ओसीईएस के 47 वें बैच से) बायोलोजी एवं रेडियोबायोलोजी में ओरियंटेशन का पाठ्यक्रम पूर्ण कर खाद्य प्रौद्योगिकी प्रभाग में सदस्यता ली। रेडीयेशन प्रिज़रवेशन यूज़िन्ग हर्डल टेक्नालोजी एन्ड रेडियेशन हाइजीनिज़ेशन इनके कायक्षेत्र की विशेषता है।

Mr. S. Saxena completed his M.Sc. (Biotechnology) in 2003 from Madurai Kamaraj Univ., Madurai. He joined the Food Technology Divn., after completing the orientation course in Biology and Radiobiology in 2004 (47th batch of OCES). His main area of work is radiation preservation using hurdle technology and radiation hygienization.


Mr. B.B. Mishra

श्री. बी. बी. मिश्रा ने वर्ष 1999 ने उत्कल विश्वविद्यालय, उडीया से एमएससी (बोटेनी) पूरा किया। इन्होंने वर्ष 2001 में (ओसीइएस के 44वें बैच से) बायोलोजी एवं रेडियोबायोलोजी में ओरियंटेशन का पाठ्यक्रम पूर्ण कर खाद्य प्रौद्योगिकी प्रभाग मे सदस्यता ली। कृषि-संबन्धी उत्पादन की रेडियेशन प्रिज़रवेशन इनके कार्यक्षेत्र की विशेषता है।

Mr. B.B. Mishra completed his M.Sc. (Botany) in 1999 from Utkal University, Orissa. He joined the Food Technology Divn., after completing the orientation course in Biology and Radiobiology in 2001 (44th batch of OCES). His main area of work is radiation preservation of agricultural products.

पी.पी. नानेकर, एम.डी. मंगसूलिकर, जे. क्लीवलेंड एवं बी.के. शाह के द्वारा लिखित, वर्ष 2007 में नॉन-डेसट्रक्टिव टेस्टिंग एन्ड इवेल्यूएशन (ऐन ऑफिशल जरनल ऑफ नॉन-डेसट्रक्टिव टेस्टिंग), जर्नल में प्रकाशित "फ्लॉ करेक्टरैज़ेशन इन पीएचडब्लूआर प्रेशर ट्यूबस् बई अल्ट्रासोनिक्स: इन्डियाज़ एक्सपीरियन्स ड्यूरिंग आइएईए सीआरपी" नामक एक तकनीकी शोध-पत्र को आर एन्ड डी की श्रेणी में सर्व श्रेष्ठ शोध-पत्र की मान्यता दी गई ।

A technical paper titled "Flaw Characterization in PHWR Pressure Tubes by Ultrasonics : India's experience during IAEA CRP", authored by P.P. Nanekar, M.D. Mangsulikar, J. Cleveland and B.K. Shah, published during the year 2007 in the Journal of Non-Destructive Testing & Evaluation (an official Journal of the Indian Society for Non-destructive Testing) was adjudged the Best Paper in the R&D category.


Mr. B.K. Shah

श्री बी.के.शाह, इस समय गुणवत्ता आश्वासन प्रभाग, भाभा परमाणु अनुसंधान केंद्र के अध्यक्ष हैं। इन्होंने रिजिनल इन्सटिट्यूट ऑफ टेक्नॉलोजी (आरआइ टी), जमशेदपुर से बीएससी. इंजीनियरिंग (मेटलर्जी) तथा इन्डियन इन्सटिट्यूट ऑफ टेक्नॉलोजी (आइआइ टी), मुंबई से एम.टेक. (कोरोषन साइंस एन्ड इंजीनियरिंग) किया है। आप भाभा परमाणु अनुसंधान केंद्र के प्रशिक्षण विद्यालय के 17 वें बैच से हैं। नाभिकीय ईंधन एवं रियक्टर कोर कंपोनंटों के उत्पादन में गुणवत्ता आश्वासन, धातुकी विशलेषणात्मक असफलता, एनडीटी के द्वारा भ्रंश एवं पदार्थ का चरित्रांकन एवं रियक्टर पदार्थ के विनाश का अध्ययन आदि इनके कार्यक्षेत्र में शामिल हैं। विभिन्न राष्ट्रीय एवं अंतर्राष्ट्रीय पत्रिकाओं एवं सम्मेलनों की प्रोसीडिंगंस् में इनके 200 से अधिक तकनीकी शोध प्रकाशित हुए हैं। आप इंडियन सोसाइटी फॉर नॉन- डेसट्रक्टिव टेस्टिंग के स्नातक एवं अन्य व्यावसायिक सोसाइटियों के आजीवन

सदस्य हैं। इन्होंने कोरोजन साइंस (2005) में श्रेष्ठता हेतु एनएसीई पुरस्कार (1998), एवं 8 तकनीकी प्रकाशनों में सर्वश्रेष्ठ शोध-पत्र पुरस्कार प्राप्त किया है।

Mr. B.K. Shah is currently Head, Quality Assurance Division, BARC. He has done B.Sc. Engg. (Metallurgy) from Regional Institute of Technology (RIT), Jamshedpur and M.Tech. (Corrosion Sc. & Engg.) from Indian Institute of Technology (IIT), Mumbai. He belongs to the 17th batch of BARC Training School. His field of work includes Quality Assurance (QA) in the manufacture of Nuclear Fuels and Reactor Core Components, Metallurgical Failure Analysis, Flaw and Material Characterization by NDT, Corrosion Studies on Reactor Materials, etc. He has published more than 200 technical papers in various National / International Journals and conference proceedings. He is a Fellow of the Indian Society for Non-Destructive Testing and Life Member of many professional Societies. He has received many Awards which include National NDT Award (1998), NACE Award for Excellence in Corrosion Science (2005) and Best Paper Award for 8 technical publications.


Mr. Paritosh Nanekar

श्री परितोष नानेकर, गुणवत्ता आश्वासन प्रभाग में पिछले 15 वर्षों से नॉन-डेसट्रक्टिव इवेल्यूएशन (एनडीई) श्रेत्र में कार्यरत हैं। डेवलोपमेंट ऑफ एनडीई टेक्नीक्स फॉर इन-सर्विस इन्स्पेक्शन ऑफ कम्पोनंटस इन न्युक्लियर फेस्लिटीज़, एडवांसड एनडीई टेक्नीक्स फॉर फ्लॉ एन्ड मेटीरियल करेक्टरैज़ेशन, क्वालिटी एशोरंस ड्यूरिंग मेनिफेक्चरिंग ऑफ रियक्टर कंपोनंटस एन्ड क्वालिटी कंट्रोल ड्यूरिंग न्युक्लियर फ्युअल फेब्रिकेशन के क्षेत्रों में इनकी विशेषज्ञता है।

Mr. Paritosh Nanekar of Quality Assurance Division is working in the field of Non-Destructive Evaluation (NDE) for the past 15 years. His areas of expertise include: Development of NDE techniques for in-service inspection of components in nuclear facilities, Advanced NDE techniques for flaw and material characterization, Quality assurance during manufacturing of reactor components and Quality Control during nuclear fuel fabrication.


Mr. M.D. Mangsulikar

एम.डी.मंगसूलिकर, गुणवत्ता आश्वासन प्रभाग पिछले 23 वर्षों से नॉन-डेसट्रक्टिव इवेल्यूएशन (एनडीई) क्षेत्र में कार्यरत्त हैं क्वालिटी कंट्रोल ड्यूरिंग फेब्रिकेशन ऑफ न्युक्लियर फ्युअल, इन-सर्विस इन्स्पेक्शन ऑफ कम्पोनंटस् इन न्युक्लियर प्लाँटस् एन्ड क्वालिटी एशोरंस ड्यूरिंग मेनिफेक्चरिंग ऑफ न्युक्लियर कंपोनंटस् के क्षेत्रों में इनकी विशेषज्ञता है।

Mr. M.D. Mangsulikar of Quality Assurance Division is working in the field of Non-Destructive Evaluation (NDE) for the past 23 years. His areas of expertise include: Quality control during fabrication of nuclear fuel, In-service inspection of components in nuclear plants and Quality assurance during manufacturing of nuclear components.

Edited & Published by :

Dr. Vijai Kumar,

Associate Director, Knowledge Management Group &

Head, Scientific Information Resource Division,

Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India.

Editorial Management : Ms. S.C. Deokattey,

Computer Graphics & Layout : B. S. Chavan, SIRD, BARC

BARC Newsletter is also available at

URL: http://www.barc.gov.in (for private circulation only)