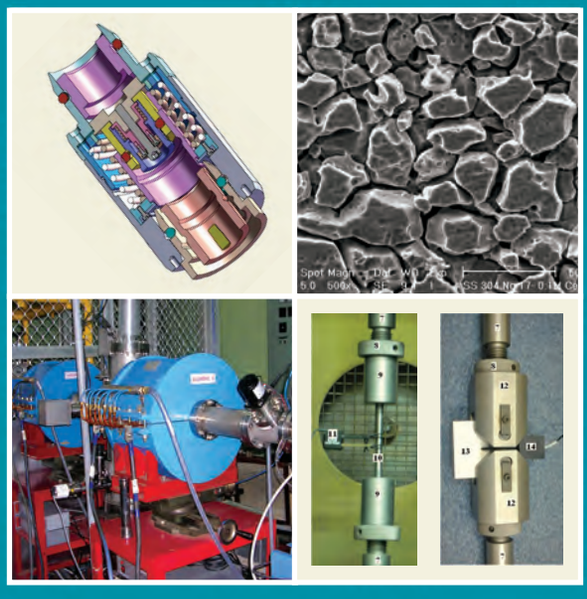
Bi-monthly • September - October • 2012

ISSN: 0976-2108

BARC NEWSLETTER

भाभा परमाणु अनुसंधान केंद्र
BHABHA ATOMIC RESEARCH CENTRE



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From the Editor's Desk

We have recently celebrated the 103rd birth centenary of our Founder, Dr. Homi Jehangir Bhabha. On this occasion, an in-depth analysis of our achievements in DAE was presented by Dr. R.K. Sinha, Chairman, Atomic Energy Commission and subsequently Shri Sekhar Basu, Director, BARC narrated major achievements of BARC. The complete text (both in Hindi and English) are covered in this issue along with various features related to the event.

This issue also includes four Brief Communications and six articles. Special mention may be made of the article "Non-invasive blood pressure monitor".

The Editorial Committee congratulates Dr. Srikumar Banerjee and Dr. Sandip Basu for their outstanding achievements.

We are of the opinion, that the diverse R&D articles covered in this issue will enable the readers to not only get to know the developments in other areas, but also arouse their curiosity.

Dr. K. Bhanumurthy
On behalf of the Editorial Committee

संस्थापक दिवस - 2012

मंगलवार, 30 अक्तुबर 2012

डॉ. रतन कुमार सिन्हा

अध्यक्ष, परमाणु ऊर्जा आयोग एवं
सचिव, भारत सरकार, परमाणु ऊर्जा विभाग
का संबोधन

डॉ. रतन कुमार सिन्हा द्वारा संबोधन

"विशिष्ट वरिष्ठजन, आमंत्रित सज्जनो, देवियो एवं प्रिय सहकर्मियो,

आज हम अपने संस्थापक डॉ. होमी जहांगीर भाभा को उनके 103वे जन्म दिवस के अवसर पर श्रद्धांजलि अर्पित करने हेतु यहां पर एकत्रित हुए है। हम इस दिवस को स्थापना दिवस के रुप में मानते हैं, और इस अवसर पर अपने हाल के कार्यप्रदर्शन का जायजा लेते है, अपने रोड-मैप के अनुसार अपने कार्यों को पुनर्योजित (रिकैलिब्रेट) करते है, तथा अपने संस्थापक के स्वप्न को कार्यन्वित करने की दिशा में स्वयं को पुनःसमर्पित करते है।

डॉ. भाभा ने भारतीय परमाणु ऊर्जा कार्यक्रम का ब्ल्यू प्रिंट सृजित कर, एक ठोस नींव रखी, जिस पर परमाणु ऊर्जा विभाग के सदस्यों की आने वाली पीढियों ने ऐसे सुपरस्ट्रक्चर निर्मित किये है, जिन्होने राष्ट्रीय विकास में महत्वपूर्ण भूमिका निभायी है।

हमारे विभाग द्वारा चालित कार्यक्रम विज्ञान एवं इंजीनियरिंग की लगभग सभी शाखाओं पर कार्यरत है। अनुसंधान, विकास, प्रदर्शन एवं उपयोग संबंधी विशिष्ट गतिविधियों ने हमे नाभिकीय ऊर्जा के इस्तेमाल के सभी पहलुओं में महत्वपुर्ण उपलब्धियों की एक विस्तृत रेंज प्रदान करने की शक्ती दी है। इन कार्यक्रमों ने हमारे उद्योगों एवं कई अनुसंधान एवं शिक्षण संस्थाओं को विकसित एवं प्रोत्साहित होने में सहायता दी है, ताकी वे हमारे विभाग की ही नही बल्कि देश की व्यापक जरुरतों को भी पूरा कर सकें।

डॉ. होमी जहांगीर भाभा के स्वप्नद्रष्टा नेतृत्व के अंतर्गत सूत्रबद्ध किए गए त्रिचरण नाभिकीय विद्युत कार्यक्रम पर निरंतर कार्यरत है। यह कार्यक्रम एक संपूर्ण न्युक्लीयर ईंधन चक्र को अंगीकृत करने की हमारी रणनीति पर जोर देता है, जिसके अंतर्गत हम सीमित पूरे संसाधनों से अधिकतम ऊर्जा प्राप्त कर सकेंगे, ताकि संधारणीय नाभिकीय अपशिष्ट प्रबंधन को सुनिश्चित कर सकें, साथ ही सबसे महत्वपूर्ण यह होगा कि थोरियम के उपयोग के द्वारा हम दीर्घकालीन ऊर्जा सुरक्षा प्राप्त कर सकेंगे। आयातित जीवाश्म ईंधन संसाधनों की लगातार बढती कीमत, और विश्वभर में बढती जा रही पर्यावरण चिंताओं को ध्यान में रखें तो हमारे देश की ऊर्जा संरक्षा में नाभिकीय ऊर्जा की महत्वपूर्ण भूमिका होगी।

घरेलू के साथ ही साथ अंतर्राष्ट्रीय श्रोतों से यूरेनियम की सप्लाइ में सुधार के कारण हमारे देश में नाभिकीय विद्युत उत्पादन बढता जा रहा हैं, और 2010-11 में इस विद्युत उत्पाद में

लगभग 23% की वृद्धि हुई है। रिएक्टरों की औसत वार्षिक उपलब्धता भी 83% से बढकर 91% हो गयी है जबकि औसत वार्षिक क्षमता गुणांक (कैपेसिटी फैक्टर) भी इस अवधी के दौरान 71% से बढकर 79% हो गया है। मार्च 2012 में 540 मेगावाट के स्वदेशी निर्मित तारापुर परमाणु बिजलीघर की युनिट -3 (टैप्स-3) ने 522 दिन की अबाध प्रचालन अवधि पूरी की। इसके साथ हमारे रिएक्टरों में से दस ने एक वर्ष से अधिक का लगातार प्रचालन पूरा किया, इनमें से तीन से 500 दिनों से अधिक का लगातार प्रचालन पूरा किया जिनमें सबसे लंबी अवधी 590 दिन थी। यह हमारी स्वदेशी प्रौद्योगिकी की परिपक्वता को प्रदर्शित करता है।

कुल मिलाकर न्युक्लीयर पावर कारपोरेशन ऑफ इंडिया लिमिटेड (एनपीसीआईएल) आज छह विभिन्न स्थलों पर बेदाग संरक्षा रिकॉर्ड के साथ बीस रिएक्टर प्रचालित कर रहा है। यह अभी तीन भिन्न-भिन्न स्थलों पर छह नये नाभिकीय विद्युत रिएक्टर निर्मित कर रहा है, जबकि भाविनि, कल्पाक्कम में प्रोटोटाइप फास्ट ब्रीडर रिएक्टर के निर्माण में रत है। स्वदेशी डिजाइन के 700 मेगावाट के चार दाबित भारी पानी रिएक्टर (PHWRs), काकरापार गुजरात में और रावतभाटा राजस्थान में पूर्व स्थित स्थलों पर 2-2 दाबित भारी पानी रिएक्टरों का निर्माण शेड्यूल के अनुसार चल रहा है, और यह वर्ष 2017 तक पूरे हो जाएंगे। 500 मेगावाट प्रोटोटाइप फास्ट ब्रीडर टेस्ट रिएक्टर का निर्माण कार्य सुचारु रुप से चल रहा है। रिएक्टर के सभी बडे उपस्करी के यथास्थान लगाने सहित, रिएक्टर वोल्ट का निर्माण एवं स्थापना गतिविधियां लगभग पूरी हो गयी है।

यह सब नाभिकीय विद्युत उत्पादन के क्षेत्र में बड़े क्षमता-विस्तरण करने की हमारी तैयारी दिखाता है। और इसलिये हमने xii वी पंचवर्षीय योजना में चार भिन्न-भिन्न स्थलों यानि हरियाना में गोरखपूर इकाइयां-1 और 2. मध्य प्रदेश में चुटका इकाइयां 1 और 2, राजस्थान में माही बोंसवाडा इकाइयां 1 और 2 और कर्नाटक में कैगा इकाइयां 1और 2, पर प्रत्येक स्थल पर 700 मेगावाट की क्षमता वाले 8 दाबित भारी पानी रिएक्टर लगाना प्रस्तावित किया है। इसके अलावा फास्ट ब्रीडर टेस्ट रिएक्टर की दो युनिटों (एफबीआर-1 और 2) और प्रगत भारी पानी रिएक्टर (ए.एच.डब्लू.आर) शुरु करने की गतीविधियां प्रारंभ करना प्रस्तावित किया है, जो कि प्रगत संरक्षा की फीचरों के साथ हमारे नाभिकीय फास्ट विद्युत कार्यक्रम के तीसरे चरण हेतु एक प्रौद्योगिकी प्रदर्शन प्लांट होंगे।

यह बडी संतोषजनक बात है कि आज संसार भारत को प्रगत नाभिकीय प्रौद्योगिकी वाले देश के रुप में मानता है, और हमारे नाभिकीय विद्युत कार्यक्रम में सहयोग हेतु आगे आ रहा है।

हमारे दो 1000 मेगावाट, के हल्के पानी रिएक्टर (एलडब्ल्यूआर) में से पहले का निर्माण कार्य कुडनकुलम में पूरा हो चुका है। इकाई-1 का प्रचालन शीघ्र ही शुरु होने वाला है और दूसरी युनिट की कमिशनिंग अगले साल के शुरु में होने की संभावना है।

विदेशी महयोग से अन्य चार नये स्थलों में से प्रत्येक पर 1000 मेगावाट या उससे अधिक के हल्के पानी रिएक्टर (एल.डब्ल्यू.आर), तामिलनाडू में कुडनकुलम (के.के. -3 और 4), महाराष्ट्र में जैतापुर (जे.एन.पी.पी.-1 और 2), आंध्र प्रदेश में कोव्वाडा इकाइयां-1 और 2 तथा गुजरात में मीठी विर्दी में इकाइयां-1 और 2 भी प्लान की गयी है।

युरेनियम अन्वेषण के क्षेत्र में विभाग ने अपनी गतीविधियों बढा दी है। परमाणु खनिज अन्वेषण एवं अनुसंधान निदेशालय के प्रयासों से, हम यूरेनियम के नये संसाधन ढूंढने में सफल हुए है, और पिछले पांच सालों में हमारे पहचाने गये रिजर्व में लगभग 70% की तेज वृद्धि हुई है। तुम्मलपल्ली डिपोजिट में देश का सबसे बडा यूरेनियम डिपोजिट बनने की क्षमता है। अभी तक स्थल पर 72,000 टन यूरेनियम की पहचान कर ली गयी है। ए.एम.डी. ने गहराई में स्थित नविनतर यूरेनियम रिजवों को ढूंढने हेतु टाइम डोमेन इलेक्ट्रो मैग्नेटिक सिस्टम प्रौद्योगिकी का उपयोग किया है। इस प्रौद्योगिकी का इस्तमाल करने वाले वायुवाहित भूभौतिकीय अन्वेषण उपस्करों के स्वदेशी विकास की प्रगति दोनों स्थानों बी.ए.आर.सी. व इं.गां.प.अ.के. पर अच्छी हो रही है।

यूरेनियम कारपोरेशन ऑफ इंडिया लिमिटेड (यू.सी.आइ.एल.) जादूगुडा क्षेत्र में खदान एवं मिलों को सफलतापूर्वक प्रचालित करता आ रहा है व तुम्मलपल्ली खदान एवं मिल के निर्माण कार्य को पांच वर्ष रेकार्ड समय में पूरा कर दिया है। तुम्मलपल्ली मिल की कमिशनिंग के साथ स्वदेशी यूरेनियम की सप्लाइ में पर्याप्त सुधार होगा, जिससे स्वदेशी यूरेनियम पर प्रचालित हो रहे हमारे नाभिकीय विद्युत रिएक्टरों के कैपेसिटी फैक्टर में भी वृद्धि होगी।

इंडियन रेअर अर्थ्स लिमिटेड (आइ.आर.ई.एल.) ओडिशा सैंड्स कांप्लेक्स, छत्रपुर, ओडिशा (ओम्काम) में 10,000 टन प्रतिवर्ष क्षमता का मोनाजाइट प्रोसेसिंग संयंत्र स्थापित कर रहा है। इस

संयंत्र को दिसंबर 2012 तक कमीशन किया जाना अपेक्षित है। इस संयंत्र में उत्पादित मिश्रित विरल मृदा क्लोराइड के एक भाग को, आइ.आर.ई.एल. के रेअर अर्थ डिवीजन, आल्वे, केरल द्वारा अपनी पहले से विद्यमान सुविधाओं का उपयोग कर पृथकीकृत उच्च शुद्धता वाले विरल मृदा ओक्साइडों के उत्पादन के लिये प्रसंस्कृत किया जाएगा।

वर्ष 2011-12 में नाभिकीय इंधन सम्मिश्र (एन.एफ.सी.) ने हमारे दाबित भारी पानी रिएक्टरों (पी.एच.डब्लू.आर.एस.) हेतु 751 टन प्राकृतिक यूरेनियम आधारित इंधन का रिकॉर्ड उत्पादन किया, जो कि पिछले वर्ष के उत्पादन से लगभग 15% अधिक है। एन.एफ.सी. ने अपने अधिकतर संयंत्रों में भी अब तक का अधिकतम उत्पादन किया है। एन.एफ.सी. ने ताप बिजलीघरों के प्रगत अल्ट्रा सुपरक्रिटिकल बॉइलरों में 47% तापगतिकीय कुशलता प्राप्त करने के लिये लक्ष्य वाली प्रौद्योगिकी को सुस्थापित करने हेतु भारत सरकार द्वारा शुरु की गयी राष्ट्रीय परियोजना के लिये इंकोनेल-617 संधिहीन ट्यूबों को रिकॉर्ड समय में सफलतापूर्वक विकसित किया, जिसके परिणामस्वरुप कार्बन-डाइ आक्साइड (co_2) का उत्सर्जन 26% कम होगा। विस्तारित हो रहे नाभिकीय विद्युत कार्यक्रम की इंधन एवं जिर्कोनियम मिश्रधातु कंपोनेंटों की जरुरतें पूरी करने हेतु अब एन.एफ.सी. नये संयंत्र लगाने की तैयारी कर रहा है।

जैसाकि आप जानते ही है, हमने अपने दाबित भारी पानी रिएक्टर कार्यक्रम हेतु नाभिकीय इंधन चक्र को सफलतापूर्वक पूरा कर दिया है। निदेशक, बि.ए.आर.सी. ने अभी कहा है कि नये रि-प्रोसेसिंग संयंत्र (प्रि.फ्री.-2) ने अपने पहले वर्ष का प्रचालन उत्कृष्ट कार्यप्रदर्शन के साथ पूरा किया है। तारापूर में इससे सटी हुई हमारी द्वितीय प्रगत विट्रिफिकेशन प्रणाली (ए.वी.एस.-2) ने 31 अगस्त 2012 से काम करना शुरु कर दिया है तथा यह उच्चस्तर के नाभिकीय अपशिष्ट के विट्रिफिकेशन (कांचीकरण) में उत्कृष्ट प्रदर्शन कर रही है। इस प्रसंग में यह और जोड़ना चाहूंगा कि हमारे छह दाबित भारी पानी रिएक्टरों से एक साथ कूलैंट चैनल हटाने के कार्यक्रम के सफल कार्वान्वयन के बाद, पहली प्रगत कांचीकरण सुविधा (AVS-1) की सफलतापूर्वक डिकमीशनिंग ने जटिल नाभिकीय डिकमीशनिंग कार्यों को करने की हमारी क्षमता को और पुष्ट किया है।

हमारे इंदिरा गांधी परमाणु अनुसंधान केन्द्र में द्रुत प्रजनक टेस्ट रिएक्टर (एफ.बी.टी.आर.) का सुचारु रुप से कार्य करना तथा वेशकीमती प्रचालन अनुभव के साथ-साथ भारत के द्रुत रिएक्टर कार्यक्रम में तकनिकी इनपुट देना जारी है। प्रोटोटाइप फास्ट ब्रीडर रिएक्टर (पी.एफ.बी.आर.) हेतु टेस्ट इंधन सबअसेम्बली के पश्च-किरणन (Post-irradiation) परिक्षा से, जोकि 112 Gwd/t के उच्चतम बर्न-अप तक पहुंचने के लिए एफ.बी.टी.आर. में किरणित करवाया गया था, बेशकीमती डाटा प्राप्त हुआ है व एफ.बी.टी.आर. ईंधन के डिजाइन व निर्माण हेतु विश्वास उत्पन्न हुआ है।

सभी प्रचालनशील भारी पानी संयंत्रों का कार्य-प्रदर्शन उत्कृष्ट रहा है और भारी पानी बोर्ड ने 100% से अधिक क्षमता उपयोगिता प्राप्त की है। भारी पानी बोर्ड ने 27 टन के तीन निर्यात आदेशों को संपन्न किया है। इसके अलावा 16 टन के दो आदेश कार्याधीन है।

अन्य इन-कोर सामग्रियों के क्षेत्र में भारी पानी बोर्ड ने पी.एफ.बी.आर. के प्रथम कोर हेतु संवर्द्धित बोरोन की पुरी मात्रा सफलतापूर्वक प्रदान की है। नाभिकीय ईंधन चक्र हेतु विलायक (साल्वेंट) के संबंध में भारी पानी संयंत्र, बड़ौदा और तालचर दोनो में नव-स्थापित आद्योगिक सुविधाओं ने बहुत अच्छा कार्य प्रदर्शन किया है।

राजा रामन्ना प्रगत प्रौद्योगिकी केन्द्र, इंदौर का इंडस-2 सिंक्रोट्रोंन विकिरण श्रोत 6/12/2012 को 2.5 GeV की ऊर्जा एवं 100mA करैट पर प्रचालन की एक बड़ी उपलब्धि पर पहुंच गया। इसने इंडस-2 से उपलब्ध विकिरण फ्लक्स को 10kev से अधिक की x-किरण ऊर्जाओं पर 20 ते 30 गुना बढा दिया है। यह वास्तव में इसलिए भी प्रशंसनीय है, क्योंकि इसने ऐसी दो अकार्यशील क्लिस्ट्रांस को, जिनका कोई रिप्लेसमेंट विदेशा में भी उपलब्ध नही था, स्वगृह में विकसित सॉलिड स्टेट आर.एफ. एंप्लिफायरों की नई प्रौद्योगिकी से रिप्लेस किया। मुझे यह कहते हुए बहुत प्रसन्नता है कि अभी हाल में इंडस-2 की प्रोटीन-क्रिस्टैलोग्राफी बीमलाइन प्रचालनशील हो गयी है। इंडस-1 और इंडस-2 हाल ही में प्रचालनशील अपनी क्रमशः 5 और 8 बीमलाइनों के साथ 24 घंटे काम कर रहे हैं, और देश के बहुत से उपयोगकर्ताओं के काम आ रहे हैं। यह इस तथ्य से स्पष्ट हो जाएगा कि जनवरी 2011 से इंडस उपयोगकर्ताओं की संख्या बढकर 164 हो गयी है और अंतर्राष्ट्रीय जर्नलों में प्रकाशित इंडस के उपयोग वाले आलेखों की संख्या 72 हो गयी है।

आरआरकेट ने सिंगल-सेल 1.3 GHz अतिचालक आरएफ कैविटी बनाने की उल्लेखनीय उपलब्धि हासिल की है। अंतर्राष्ट्रीय

मानकों के समकक्ष त्वरक प्रवणता (एक्सीलरेटिंग ग्रेडिएंट) और गुणवत्ता कारक प्रदान किये है। इसके आगे जैसाकि आपको ज्ञात ही होगा, राजा रामन्ना प्रगत प्रौद्योगिकी केन्द्र लेसर, विशेषकर जैव-चिकित्सा, लेसर-प्लाज्मा पारस्परिक क्रियाओं (इंटरएक्सन) और औद्योगिक अनुप्रयोगों में उल्लेखनीय योगदान कर रहा है। यहां में उनके द्वारा सर्वप्रथम बार विकसित अतिचालकता वाली नियोबियम कैविटी की लेसर-वेल्डिंग की नई तकनीक का उल्लेख अवश्य करना चाहूंगा जिसके लिए एक अंतर्राष्ट्रीय पेटेंट हेतु आवेदन किया गया है।

परिवर्ती ऊर्जा साइक्लोट्रोन केन्द्र (वीईसीसी) कोलकाता में k-130 रुम टेंप्रेचर साइक्लोट्रोन बहुत अच्छा तरीके से चल रहा है और बीम प्रदान कर रहा है, जिन्हें नाभिकीय भौतिकी नाभिकीय रसायनशास्त्र के विभिन्न प्रयोगों एवं रेडियो-समस्थानिक उत्पादन हेतु उपयोग किया जा रहा है। इसे हाल ही में ओक्सिजन-14 एवं पोटासियम-40 की पहली रोडियोसक्रिय आयन बीम को सृजित एवं त्वरित करने में उपयोग किया गया है। वीईसीसी में कमिशनिंग किये जा रहे सुपरकंडक्टिंग साइक्लोट्रोन से शिघ्र ही बाह्य बीम प्रदान किया जाना संभावित है।

विकीरण और आइसोटोप प्रौद्योगिकी बोर्ड (ब्रिट) ने दो रेडिएशन प्रोसेसिंग संयंत्रों को प्रचलित करने के अलावा प्राइवेट सेक्टर में नौ (09) रेडिएशन संयंत्रों की डिजाइन निर्माण और प्रचालन में सहायता की है। ऐसे और छह संयंत्र निर्माणाधीन हैं तथा अन्य आठ प्राइवेट उद्यमियों के साथ समझोता ज्ञापन पर हस्ताक्षर किये गये हैं। यह संयंत्र डिस्पोजेबल मेडिकल वस्तुओं, मसालों, पशु चारा, एवं आयुर्वेदिक तथा वानस्पतिक उत्पादों का प्रसंस्करण करते है। यह हमारे देश के खाद्य-परिरक्षण एवं स्वास्थ्यकरण कार्यक्रम में योगदान दे रहे है।

स्वास्थ्य देखभाल (हेल्थ केअर) के क्षेत्र में भारत की पहली मेडिकल साइक्लोट्रोन फैसिलिटी (MCF) जो पोजिट्रोन एमिसन टोमोग्राफी (पीइटी) हेतु ट्रेसरों के उत्पादन के लिये बीएआसी में स्थापित की गयी थी, ने इस माह अपने सफल प्रचालन के 10 साल पूरे कर लिए है। यह प्रसन्नता की बात है कि प्राइवेट मेडिकल संस्थानों सहित, भारत में इस प्रकार की सुविधाओं का समानांतर विकास हो रहा है। वर्तमानतः भारत में 16 मेडिकल साइक्लोट्रोन एवं 70 पीइटी-सीटी यूनिटें है, जो रोगियों को नाभिकीय औषध सेवाएं दे रही है।

हाल ही में सर्न स्थित लार्ज हेड्रोंन कोलाइडर (एलएचसी), एटीएलएएस (ए टोरोंइडन एल.एच.सी. एपरेटस) और सीएमएस (काम्पैक्ट म्युओंन सोलेनाइड) ने एक नई अनुदान (रेजोनेंस) का प्रेक्षण किया हैं जिसके हिग्स बोस्सोन होने की संभावना है। इसकी भविष्यवाणी से 50 वर्ष तक इस स्थिति की विस्तृत रुप से खोज की गयी थी और इसकी खोज से एलएचसी परियोजना की प्राथमिक भौतिकी और प्रेरणा परिपूर्ण होती है। पऊवि इस खोज में सहभागी होकर गौरवान्वित है क्योंकि इसकी संस्थाएं बहुत लंबे समय तक एलएचसी मशीन, डिटेक्टरों, प्रयोगों एवं ग्रिड कम्प्यूटिंग से संबंधित प्रयासों में सम्मिलित रही है।

उच्च ऊर्जा भौतिकी में टीआइएफआर वैज्ञानिकों सहित सशक्त अंतर्राष्ट्रीय सहयोग के फलस्वरुप सर्न जेनेवा, हेड्रोंन कोलाइडर पर बाहरी हेड्रोंन केलोरीमीटर की स्थापना करने में सफलता मिली। भारत स्थित न्यूट्रिनों प्रेक्षणशाला (ओब्जवेंटरी) के लिए डिटेक्टरों के एक आवश्यक पुर्जे यानि रेसिस्टिक प्लेट चेंबर (आरपीसी) का विनिर्माण शुरु हो गया है।

जैसेकि आपको ज्ञात होगा कि हरिश्चन्द्र अनुसंधान संस्थान के डॉ. अशोक सेन को स्ट्रिंगथ्योरी पर उनके काम के लिए रुसी भौतिकशास्त्री एवं उद्यमी यूरी मिलनर द्वारा स्थापित फंडामेंटल फिजिक्स प्राइज फाउन्डेशन द्वारा, प्रतिष्ठित फंडामेंटल फिजिक्स पुरस्कार प्राप्त हुआ है। हम, पउवि परिवार के लोग हमारे परिवारजनों में से एक की इस उपलब्धि से बहुत गौरवान्वित है।

मानव संसाधन विकास भी एक ऐसा क्षेत्र है, जिसमे हम डॉ. भाभा की दूरदृष्टि से बहुत लाभान्वित हुए हैं। तथापि निकट भविष्य में होने वाले बड़े विस्तार द्वारा प्रस्तुत की गई चुनौतियां, नये प्रौद्योगिक क्षेत्र, जिन पर हमें काम करना है, तथा बाहरी आकर्षण बिंदु इस सब पर नई पहेलों की जरुरत है। होमी भाभा नेशनल इंस्टिट्यूट (एच.बी.एन.आइ.) में हमारे वैज्ञानिक व इंजीनियर पी.एच.डी. कार्यक्रमों हेतु बडी मात्रा में निरंतर पंजीकरण करवा रहे हैं।

मुझे यह सूचित करते हुए बहुत खुशी है कि मानव संसाधन विकास मंत्रालय द्वारा गठित एक कार्यबल ने होमी भाभा नेशनल इंस्टिट्यूट (एच.बी.एन.आइ.) को कैटेगरी "ए" में रखा है तथा मानव संसाधन विकास मंत्रालय में रिपोर्ट को स्वीकार कर लिया है। अध्ययन एवं अनुसंधान के एक परिश्रम-साध्य कार्यक्रम के माध्यम से शैक्षणिक उत्कृष्टता पाना ही एचबीएनआइ की कार्यप्रणाली का केन्द्र बिंदु होना चाहिए और ऐसा कर पाना तभी संभव होगा जब प्रत्येक संकाय-सदस्य दैनंदिन कार्य में उत्कृष्टता एवं परिश्रम को आत्मसात कर लें। मैं इस अवसर

पर आप सबसे निवेदन करता हूँ कि शैक्षणिक उत्कृष्टता एवं परिश्रम का हर स्तर पर पालन किया जाना चाहिए; चाहे वह प्रवेश हो या कक्षा अध्यापन, परीक्षा में विद्यार्थियों के कार्य-प्रदर्शन का मूल्यांकन, अनुसंधान थीसिस और शोध के मूल्यांकन सहित प्रकाशन कार्य। हमें यू.जी.सी. के सभी लागू मार्गनिर्देशों का पालन करना होगा। हमारा विज्ञान शिक्षण हेतु होमी भाभा केन्द्र (एच.बी.सी.एस.ई) विद्यार्थियों को विभिन्न विज्ञान ओलंपियाड में भाग लेने हेतु प्रशिक्षित कर रहा है। मार-डेल-प्लाय, अर्जेंटीना में जुलाई 4-16, 2012 तक आयोजित 53वें अंतर्राष्ट्रीय गणित ओलंपियाड में 6 सदस्यीय भारतीय टीम ने 2 स्वर्ण, तीन रजत पदक और एक (01) प्रतिष्ठात्मक उल्लेख प्राप्त किया।

"प्रिय साथियों,

मैंने अभी-अभी हमारे विभाग द्वारा पिछले वर्ष प्राप्त कुछ बड़ी उपलब्धियां का विशेष उल्लेख किया है। हमारी उपलब्धियां बेशक प्रभावशाली रही है। अब मैं आपके साथ कुछ अंतर्राष्ट्रीय अनुभव बांटना चाहता हूँ। मार्च 2011 के जापान स्थित फुकुशिमा दुर्घटना के प्रति विश्व की प्रतिक्रिया काफी परिपक्व रही, जहां उस दुर्घटना से सुरक्षा बढ़ाने के पूरे सबक सीखने के लिये प्रतिबद्धता दिखायी गयी है, वही नाभिकीय विद्युत के विकास का पूर्वेक्षण दीर्घकालीन विकासात्मक उद्देश्यों का पूरा करने हेतु ऊर्जा सुरक्षा के प्रति चिंता से चालित है। यह इस बात से भलीभांति स्पष्ट है, जब हम देखते हैं कि फुकुशिमा के बाद पांच विभिन्न देशों में सात नव-निर्मित रिएक्टर, ग्रिड से जोड़े गये। इसके अलावा भारत सहित कई देश अपने नाभिकीय ऊर्जा के विस्तार कार्यक्रम को जारी रखे हुए है, साथ ही नाभिकीय संरक्षा पर भी अतिरिक्त जोर दे रहे है। यहां पर आइ.ए.ई.ए. के नविनतम अनुमानों का उल्लेख करना समुचित होगा, जो आने वाले दशकों में विश्व में नाभिकीय बिजली लगातार वृद्धि दर्शा रहे हैं।

इन इंगितों के बावजूद फुकुशिमा दुर्घटना ने संबंधित लाभों के समक्ष नाभिकीय ऊर्जा से जुडे खतरों के जनसामान्य की अवधारणा के मुद्दे को संतोषजनक एवं संधारणीय तरीके से संबंधित करने की त्वरित आवश्यकता को रेखांकित किया है।

हाल के समय में प.ऊ. विभाग की विभिन्न इकाइयों ने अपनी जनसामान्य से संबंधित गतिविधियों में बहुत वृद्धि की है, जिसके परिणाम भी नजर आ रहे हैं। हम मीडिया-वर्कशॉप की एक श्रृंखला आयोजित करने, एवं हमारी जन-सूचना संबंधी अधिकांश सामग्री को क्षेत्रीय भाषाओं में अनुदित करने की योजना भी बना रहे हैं। देश में केवल हमारे द्वारा ही नही, बल्की अन्य अनुसंधान एवं शैक्षणिक संस्थाओं द्वारा संबंधित विषयों पर किये गये अध्ययनों पर आधारित तथ्यों का सहज, सरल भाषा में सही तरफ से प्रसारण करने से हमारी सुविधाओं के प्रचालन से निकलने वाले हानिकारक प्रभावों के बारे में फैली मिथ्या धारणाओं को दूर करने में मदद मिलेगी।

इस दिशा में अगली गतिविधि है, वर्तमान रेडिएशन बचाव विचारधारा में अंतर्ग्रथित परंपरावाद की अत्यधिक उच्च मात्राओं को स्पष्टतया पहचानना। इस दिशा में हमने पहले से उपलब्ध वैज्ञानिक नतीजों को समेकित करने एवं अनुसंधान के नए क्षेत्रों की पहचान करने हेतु एक विज्ञान आधारित कार्यक्रम की शुरुआत कर दी है, जो ऐसी सीमाओं को निर्धारित करेगा,जिन सीमाओं कम रेडिएशन का मानवों पर कोई असर नही होता है। हम ऐसी अनुसंधान गतिविधियों में अंतर्राष्ट्रीय सहयोग भी तलाश रहे है।

प्रिय साथियों, परमाणु ऊर्जा विभाग ने अपने पांच दशक से भी अधिक के इतिहास में अपने कार्यक्रमों के विकास में आने वाली अनेक चुनौतियों पर विजय पायी हैं। ऐसी प्रत्येक चुनौती से हमें इन बाधाओं पर का संकल्प तथा दृढ निश्चय मिला है। मुझे पूरा विश्वास है कि परमाणु ऊर्जा विभाग परिवार के प्रत्येक सदस्य तथा हमारे सहयोगियों के योगदान से, हम आने वाले वर्षो में लगातार उत्साह तथा ऊर्जा से अपने कार्यक्रमों को आगे बढाएंगे। हमे यह याद रखना चाहिए कि आगे अपनी प्रगति की राह में प्राप्त की गई हमारी प्रत्येक उपलब्धि, वास्तव में हमारे संस्थापक डॉ. होमी जहॉगीर भाभा तथा विभाग के अन्य पथ-प्रदर्शकों को हमारी श्रद्धांजलि होगी।

धन्यवाद,

जयहिंद।"

Founder's Day 2012

Address by
Dr. Ratan Kumar Sinha
Chairman, Atomic Energy Commission &
Secretary to Government of India, Department of Atomic Energy

"Distinguished seniors, invitees and dear colleagues,

Today we have assembled here to pay homage to our founder Dr. Homi Jehangir Bhabha on the occasion of his 103rd birth anniversary. We celebrate this day as Founder's day and on this occasion take stock of our recent performance, recalibrate our actions vis-à-vis our road map and rededicate ourselves to realise the vision of our Founder.

Dr. Bhabha created a blueprint for the Indian Atomic Energy Programme and laid a solid foundation on which successive generations of members of the DAE family have built the superstructures that have played an important role in national development.

The programmes pursued by our Department cover almost all the scientific and engineering disciplines. The specific activities addressing Research, Development, Demonstration and Deployment have given us the strength to provide a vast range of key deliverables in all aspects of use of nuclear energy. These programmes have helped the development and growth of our industries and also several research and academic institutions to cater not only to the needs of our Department, but also to the requirements of the country at large.

The Department continues the pursuit of three-stage nuclear power programme, formulated under the visionary leadership of Dr. Homi Jehangir Bhabha. This programme underlines our strategy of adopting a closed nuclear fuel cycle to extract the maximum energy from the limited uranium resources, to ensure sustainable nuclear waste management and, above all, to achieve long-term energy security through utilisation of thorium. With the rising cost of imported fossil fuel resources and the mounting environmental concerns being raised the world over, nuclear energy has an important role to play in the energy security of our country.

Nuclear power generation in our country continues to grow due to the improvement in supply of uranium from domestic as well as international sources, and in 2011-12, it has registered an increase of about 23% over that generated in 2010-11. The average annual availability of the reactors has also increased from 83% to 91%, while the average annual capacity factor has increased from 71% to 79% during the same period.

In March 2012, the 540 MW, indigenously built Tarapur Atomic Power Station unit-3 (TAPS-3), achieved a period of uninterrupted operation lasting 522 days. With this, till date, ten of our reactors have had continuous runs of over a year, with three of them registering over 500 days of continuous run, the longest being 590 days. This demonstrates the maturity of our indigenous technology.

In all, today, Nuclear Power Corporation of India Ltd. (NPCIL) is operating twenty nuclear power reactors at six different sites, with unblemished safety record. It is currently constructing six new nuclear power reactors at three different sites, while BHAVINI is engaged in construction of Prototype Fast Breeder Reactor at Kalpakkam. Construction of four indigenously designed 700 MW PHWRs, two each at existing sites of Kakrapar in Gujarat and Rawatbhata in Rajasthan, is on schedule and these will be completed by the year 2017. The construction of the 500 MW Prototype Fast Breeder Reactor (PFBR) is progressing well at Kalpakkam. The construction and installation activities in the

Reactor Vault are nearly complete, with all the major reactor equipment in place.

All this demonstrates our readiness to undertake larger capacity expansion in the field of nuclear power generation and hence in the XII Plan we have proposed to launch eight PHWR reactors of 700 MW capacity each at four different sites viz Gorakhpur Units -1&2 in Haryana, Chutka Units - 1&2 in MP, Mahi Banswara Units - 1&2 in Rajasthan and Kaiga Units - 5&6. It is also proposed to initiate activities towards the launch of two units of Fast Breeder Reactors (FBR-1&2), and Advanced Heavy Water Reactor (AHWR), which would be a technology demonstration plant, for the third stage of our nuclear power programme, with advanced safety features.

It is a matter of great satisfaction that the world today recognises India as a country with advanced nuclear technology and is coming forward to collaborate in our nuclear power programme.

The work on the construction of the first of the two 1000 MW Light Water Reactors (LWRs) at Kudankulam is complete. The operation of unit-1 is expected to commence shortly and the commissioning of the second unit is expected to follow early next year.

Light Water Reactors (LWRs), with international cooperation, each of capacity 1000 MW or more at another four different sites viz Kudankulam in Tamil Nadu (KK-3&4); Jaitapur in Maharashtra (JNPP-1&2); Kovvada Unit-1&2 in Andhra Pradesh; and Mithi Virdi Unit-1&2 in Gujarat are also planned.

In the areas of Uranium exploration, the Department has enhanced its activities. Due to the efforts of Atomic Minerals Directorate for Exploration and Research (AMD), we have been able to identify new resources of Uranium, and in the last five years, our identified reserves have registered a steep increase of about 70%. The Tummalapalle deposit holds the promise to be the biggest deposit of uranium in the country. As of now about 72,000 tons of uranium deposit has been identified at the site. AMD has used the technology of Time Domain Electro Magnetic system for finding deep seated newer uranium reserves. Indigenous development of airborne geophysical exploration equipment using this technology has progressed well, both at BARC and IGCAR.

Uranium Corporation of India Ltd (UCIL) has been successfully operating mines and mills at Jaduguda region and has constructed Tummalapalle Mine and Mill in a record time of five years. With the commissioning of the Tummalapalle mill, there would be substantial improvement in the supply of indigenous uranium, which will further increase the capacity factors of our nuclear power reactors operating on indigenous uranium.

The Indian Rare Earths Limited (IREL) is setting up a 10,000 ton per annum Monazite processing plant at Odisha Sands Complex, Chatrapur, Odisha (OSCOM). The plant is expected to be commissioned by December 2012. A part of the mixed rare earths chloride produced in the Plant will be processed by IREL's Rare Earths Division, Aluva, Kerala, by using the existing facilities there for producing separated high purity rare earth oxides.

In the year 2011-12, Nuclear Fuel Complex (NFC) has recorded a production of 751 tons natural uranium based fuel for our Pressurised Heavy Water Reactors (PHWRs), which is an increase of about 15% over the production in the previous year. NFC has also achieved the highest ever production from most of its plants. NFC has successfully developed Inconel-617 seamless tubes in a record time for a national project, initiated by the Government of India, to establish the technology for Advanced Ultra Supercritical Boilers in Thermal Power Plants, aimed at achieving a thermodynamic efficiency of 47%, with a consequent reduction of 26% in carbon- di-oxide (CO_2) emissions. NFC is now gearing up to set up new plants to fulfil the needs of the fuel and zirconium alloy components for the expanding nuclear power programme.

As you are aware, we have successfully closed the nuclear fuel cycle for our PHWR programme. Director BARC has just now stated that the new reprocessing plant (PREFRE-2), has completed the first year of its operation with outstanding performance. The adjoining facility of our second advanced vitrification system (AVS-2) at Tarapur started functioning from 31st August 2012 and has been giving excellent performance in the vitrification of high level nuclear waste. In this context, I will like to add that the successful decommissioning of the first advanced vitrification facility (AVS-1) has further underlined our technological strength to undertake complex nuclear decommissioning tasks, after the successful en-masse coolant channel removal programme implemented at six of our PHWRs.

At our Indira Gandhi Centre for Atomic Research (IGCAR), the Fast Breeder Test Reactor (FBTR) has continued to operate smoothly, providing valuable operating experience as well as technical inputs to India's fast reactor programme. Post-irradiation examination of the test fuel subassembly for the Prototype Fast Breeder Reactor (PFBR), which was irradiated in FBTR to reach a peak burn-up of 112 GWd/t, has provided valuable data and generated confidence in the design and manufacture of the FBR fuel.

Performance of all the operating Heavy Water Plants has continued to be excellent and the Heavy Water Board has achieved more than 100% capacity utilisation. HWB has executed three export orders of 27 tons. In addition, two orders of 16 tons are in pipeline.

In the field of other in-core materials, HWB has successfully delivered the entire quantity of enriched boron for the first core of PFBR. In respect of solvent for nuclear fuel cycle, both the newly installed industrial facilities at HWP Baroda and Talcher have performed very well.

Indus-2 synchrotron radiation source at Raja Ramanna Centre for Advanced Technology (RRCAT), Indore, reached a major milestone of operation at design energy of 2.5 GeV and 100 mA current on December 6, 2011. This has increased the radiation flux available from Indus-2 by a factor of 20 to 30 at X-ray energies above 10 keV. It is really praiseworthy that this has been accomplished with the support of in-house developed new technology of Solid State RF Amplifiers to replace two non-functional klystrons, for which no replacements were available from abroad. I am happy to say that very recently the protein crystallography beam line of Indus-2 has become operational. Indus-1 and Indus-2, with their 5 and 8 beamlines operational respectively, are working round-the-clock and serving a large community of users in the country. This may be evident from the fact that since January 2011, the total number of Indus users have gone up to 164 and the number of papers published in international journals using Indus to 72.

RRCAT has also made remarkable accomplishments of building single-cell 1.3 GHz superconducting RF cavities which have provided accelerating gradient and quality factor comparable to international standards. Next, as you would be aware that RRCAT is making notable contributions in the area of lasers, particularly in bio-medical, laser-plasma interaction and industrial applications. I would like to mention about their first ever development of new technique of laser welding of superconducting niobium cavity, for which an international patent has been applied for.

The K-130 Room Temperature Cyclotron at Variable Energy Cyclotron Centre (VECC), Kolkata has been operating extremely well and delivering beams, which are being used for various experiments on nuclear physics, nuclear chemistry and radio isotope production. It has been used recently to produce and accelerate the first radioactive ion beam of Oxygen-14 and Potassium-40. The superconducting cyclotron, under commissioning at VECC, is expected to deliver external beam soon.

The Board of Radiation and Isotope Technology (BRIT), apart from operating two Radiation processing plants, has helped in design, construction and operation of nine radiation processing plants in the private sector. Six such plants are under construction and MoUs have been signed with another eight private entrepreneurs. These plants are processing disposable medical items, spices, pet feed and ayurvedic & herbal products. They are contributing towards food preservation and hygenisation programme of our country.

In the area of health care, the first Medical Cyclotron Facility (MCF) of India, set up in BARC for production of tracers for positron emission tomography (PET), has completed ten years of successful operation this month. It is heartening to report the considerable parallel growth of similar facilities in India, including those in private medical institutions. Currently, there are 16 medical cyclotrons and 70 PET-CT units in India, providing nuclear medicine services to patients.

Recently, two major experiments at the Large Hadron Collider (LHC) at CERN, ATLAS (A Toroidal LHC Apparatus) and CMS (Compact Muon Solenoid), have announced the observation of a new resonance which is likely to be the Higgs Boson. This state has been searched extensively for almost 50 years since its prediction and the discovery fulfils the primary physics motivation for the existence of the LHC project. DAE is proud to be a part of this quest, in which its institutions have been involved for a long time with participation in efforts related to the LHC machine, the detectors, the experiments, as well as Grid computing.

In high energy physics, strong international collaborations involving TIFR scientists culminated in the installation of the outer hadron calorimeter at the Large Hadron Collider (LHC) in CERN, Geneva. Fabrication of Resistive Plate Chambers (RPCs), an essential part of the detectors for the India-based Neutrino Observatory, has begun.

As you may be aware, very recently Dr. Ashoke Sen of Harishchandra Research Institute has received the prestigious Fundamental Physics Prize awarded by the Fundamental Physics Prize Foundation founded by the Russian physicist and entrepreneur Yuri Milner, for his work on string theory. We, in the DAE family are very proud in this achievement of one of our family members.

Human resource development is another area where we have immensely benefited from the foresight of Dr. Bhabha. However, the challenges posed by the major expansion that we foresee in our programme, new technological areas that we need to work on and the external attractions necessitate new initiatives. Homi Bhabha National Institute (HBNI) continues to register large number of our scientists and engineers for the PhD programme.

I am glad to inform that very recently a task force set by Ministry of Human Resource Development (MHRD) has placed Homi Bhabha National Institute (HBNI) in category 'A' and the MHRD has accepted the report. Pursuit of academic excellence through a rigorous programme of study and research should be central to functioning of HBNI and it is possible to do so if every faculty member imbibes excellence and rigour in day to day working. I take this opportunity to request all of you that academic excellence and rigor has to be observed at all levels; admissions, class room teaching, evaluation of students performance in examinations, research, publications including theses and evaluation of research. We also have to continue to follow all UGC guidelines as applicable.

Our Homi Bhabha Centre for Science Education (HBCSE) has been training students to participate in various Science Olympiads. Six-member Indian team secured 2 Gold and 3 Silver medals and 1 Hon'ble mention at the 53rd International Mathematical Olympiad held at Mar del Plata, Argentina from July 4-16, 2012.

Dear Colleagues,

I have just highlighted some of the major achievements that have been accomplished by the Department during the last year. While our achievements have been impressive, let me share with you some international experiences. The Global response to the Fukushima accident of March 2011 at Japan, by and large, has been very mature. While committing to learn complete lessons from the accident to enhance safety, the growth prospect of nuclear power continues to be driven by the concerns of energy security to meet long term developmental goals. This is aptly demonstrated when we note that post-Fukushima, seven newly constructed reactors in five different countries have been connected to the grid, and that many newcomer countries have decided to continue with their policy for launch of nuclear power programme. Furthermore, many countries, including India have continued with their programme for expansion of nuclear power, while simultaneously placing additional emphasis on nuclear safety. It is, thus, pertinent to note the latest IAEA projections, which show a continued growth for nuclear power in the world, in the coming decades.

Notwithstanding these indications, the Fukushima accident underscored the urgency for satisfactorily and sustainably addressing the issue of public perception of relative benefits, vis-a-vis the risks of nuclear energy.

In the recent past, the different units of the Department of Atomic Energy have vastly enhanced their public outreach activities with visible results. We are also planning to hold a series of media workshops and translate most of our public information related material into regional languages. This will also help in dispelling the myths concerning the harmful effects of radiation arising out of operation of our facilities through due dissemination, in a simple language, of the facts based on the studies on related issues already carried out in the country, not only by us, but also by other research and academic institutions.

Another activity in this direction is to clearly identify the very high margins of conservatism inherent in the existing radiation protection philosophy. In this direction, we have already initiated a science based programme to consolidate the already available scientific findings and identifying new areas of research to address the thresholds, below which no harmful effects of radiation do take place in human beings. We are seeking international collaborations in such research activities.

Dear colleagues, in our history of more than five decades we have overcome numerous challenges coming in the path of growth of our programme. Each such challenge has given us a greater resolve and determination to work even harder to overcome the hurdles. I am quite sure that with the contributions from every member of the DAE family and our collaborators, we will carry forward our programme with continued enthusiasm and vigour in the years to come. Let us remember that each milestone reached in our march to further progress is, in fact, our tribute to our founder Dr. Homi Jehangir Bhabha and the other pioneers of our department.

Thank you,

Jai Hind."

संस्थापक दिवस - 2012

मंगलवार, 30 अक्तूबर, 2012

श्री. शेखर बसु

निदेशक, भाभा परमाणु अनुसंधान केंद्र

का संबोधन

श्री. शेखर बसु द्वारा संबोधन

"परमाणु ऊर्जा आयोग के अध्यक्ष डॉ. सिन्हा, परमाणु ऊर्जा विभाग परिवार के वरिष्ठ सदस्यगण, विशिष्ट आमंत्रित अतिथिगण, मीडिया के प्रतिनिधिगण, मेरे प्रिय साथियों और दोस्तों ।

मैं, संस्थापक दिवस के शुभ अवसर पर प्रभात की इस बेला में आप सभी का हार्दिक स्वागत करता हूँ। आज हम अपने स्वप्नद्रष्टा डॉ. होमी जहांगीर भाभा के 103वें जन्मदिवस के अवसर पर उन्हें भावपूर्ण श्रद्धांजलि अर्पित करते हैं। हम यहां एकत्रित हुए हैं ताकि हम अपने पिछले वर्ष के कार्य निष्पादन एवं उपलब्धियों का विश्लेषण कर सकें और नाभिकीय अनुप्रयोगों से अपने समाज को अधिक से अधिक लाभ पहुँचाने के लिए अनवरत सर्वोत्कृष्ट कार्य करते रहने के लिए अपने आप को पुनः समर्पित कर सकें।

सबसे पहले मैं पिछले वर्ष के दौरान प्राप्त की गई मुख्य उपलब्धियों का विवरण आपके सामने रखना चाहूंगा।

A.1 कार्प और प्रिफ्री -2 के प्रचालन से पुनर्संसाधन कार्यक्रम में व्यापक सुधार हुआ है और इसकी क्षमता के उपयोग के सर्वोत्कृष्ट रिकॉर्ड स्थापित किए गए। नए पुनर्संसाधन संयंत्र (प्रिफ्री-2) के प्रचालन का एक वर्ष उत्कृष्ट कार्यनिष्पादन के साथ पूर्ण हुआ जो उत्पादन एवं प्रक्रम प्राचल दोनों तरह से सर्वोत्तम रहा।

A.2 गंभीर दुर्घटना के दौरान स्तरित शीतलक चैनल का अनुकरण करते हुए दाबित भारी पानी रिएक्टर दाब नलिका बैलूनिंग प्रयोग किए गए। दाब नलिका एवं कैलेंड्रिया ट्यूब के संपर्क के बाद प्रेशर ट्यूब हीट-अप कम होता पाया गया, इस तरह दाबित भारी पानी रिएक्टरों के लिए हीट सिंक को मॉडरेटर के रूप में स्थापित किया गया ।

A.3 इंजेक्शन कास्टिंग द्वारा सभी विशिष्टताएं पूरी करने वाले प्राकृतिक एवं समृद्ध U-6wt%Zr मिश्रधातु ईंधन स्लग बनाकर एफबीटीआर में सोडियम बांडिंग एवं टेस्ट किरणन के लिए आईजीकार को भेजे गए ।

A.4 95% तक की आर्द्रता तक ठीक-ठीक काम करने वाले और (CO_2, CO, SO_2 एवं NO_2 के लिए) पॉल्यूटेंट गैस सैंसरों हेतु ऑपशनल कनेक्शन के साथ फिट किए जा सकने वाले कस्टमाइज्ड ऑनलाइन रेडॉन मॉनिटर्स का स्वदेश में ही अभिकल्पन एवं संविरचन किया गया और उन्हें तुरामडीह खान में स्थापित किया गया। माइन वेंटीलेशन सिस्टम के प्रभावशाली प्रबंधन एवं खान में

कार्यरत कामगारों में विकिरण डोज के इष्टतमीकरण के लिए इनका उपयोग किया गया ।

A.5 ताज़ी लीचियों को लम्बे समय तक सुरक्षित रखने के लिए एक प्रौद्योगिकी का विकास किया गया और महाराष्ट्र के किसानों को इसकी जानकारी दी गयी ; इस प्रौद्योगिकी का हस्तांतरण भी कर दिया गया है।

A.6 भारत के राजपत्र में प्रकाशन हेतु परमाणु ऊर्जा नियमावली 2012 (खाद्य एवं संबंधित उत्पादों का विकिरण संसाधन) को परमाणु ऊर्जा विभाग द्वारा अधिसूचित किया गया। इन नए नियमों से अंतर्राष्ट्रीय एवं घरेलू बाज़ारों के सेनीटरी एवं फाइटो-सेनीटरी मानकों पर खरा उतरने के लिए व्यापक उत्पाद रेंज पर खाद्य किरणन प्रौद्योगिकी के व्यावसायिक उपयोग को बढ़ावा मिलेगा।

A.7 वर्षा जल संरक्षण कार्यक्रम के अंतर्गत, लगभग 300 मिलियन लीटर पानी प्रतिवर्ष इकट्ठा करने की परियोजना लागू की गई जिससे ट्रांबे पहाड़ियों की तलहटी में स्थित झील क्रमांक 11 से बारिश के पानी के प्रभावी उपयोग द्वारा एक करोड़ रुपए वार्षिक की बचत हुई।

A.8 Nb-Ti से निर्मित अतिचालक केबल-इन कन्डक्टर का संविरचन किया गया और 30 kA क्षमता के 100 मीटर लंबे तार को एएफडी स्थित एक 2 मीटर व्यास वाले बॉबिन पर लपेट कर प्लाज्मा अनुसंधान संस्थान को भेज दिया गया।

A.9 भापअ केंद्र, CERN-LHC की कांपैक्ट म्यूऑन सालिनॉइड (CMS) डिटेक्टर की उस टीम का एक हिस्सा है जिसने प्रयोगात्मक रूप से हिग्स बोसॉन (Higgs Boson) की खोज की है। भापअ केंद्र की टीम ने भा. इ. लि. (BEL) के साथ मिलकर 100 से अधिक सिलिकॉन सेन्सरों की आपूर्ति की है। हिग्स बोसॉन की खोज पर सर्वप्रथम प्रकाशित पेपर में भापअ केंद्र के वैज्ञानिकों के नाम का उल्लेख किया गया है।

A.10 केरल के तटों पर स्थित उच्च एवं सामान्य स्तर के प्राकृतिक विकिरण वाले क्षेत्रों में नवजात शिशुओं पर व्यापक अध्ययन हाल ही में पूरे किए गए हैं। उच्च एवं सामान्य विकिरण स्तर क्षेत्रों के नवजातों शिशुओं में गुणसूत्र विपथन एवं कारियोटाइप विसंगतियों की आवृतियां समान थीं और विकिरण डोज से संबंधित कोई नयी प्रवृति नहीं दिखाई दी।

A.11 दो संहत स्पंद शक्ति प्रणालियां विकसित की गई हैं जिनके नाम हैं :- 400 KeV रैखिक प्रेरण त्वरक एवं 300 kV संहत स्पंद शक्ति प्रणाली । ये प्रणालियां उच्च शक्ति माइक्रोवेव जनरेशन के लिए क्रमशः उच्च शक्ति चुंबकीय स्पंद संपीडन स्विचों तथा एक्स्प्लोडिंग वायर ऐरे स्विच पर आधारित हैं। औद्योगिक एवं नाभिकीय अनुप्रयोगों के लिए कोल्ड वेल्डिंग हेतु सिंक्रोनाइज्ड स्पार्क गैप स्विचों का प्रयोग करके एक 20 kV, 40 kJ शक्ति की इलेक्ट्रोमैग्नेटिक फार्मिंग तथा वेल्डिंग मशीन का विकास किया गया।

A.12 पूरे भारत के वैज्ञानिकों के बड़े समूह द्वारा उपयोग की जाने वाली प्रोटीन क्रिस्टलोग्राफी बीम लाइन का कमीशनन इंडस-2, आरआरकैट में कर लिया गया है।

A.13 प्रगत उपस्कर सहित एक आइसोटोप हाइड्रोलॉजी प्रयोगशाला हिमालय पर्यावरणीय अध्ययन तथा संरक्षण संगठन देहरादून में स्थापित की गयी है ताकि स्थानीय लोगों को स्प्रिंग रिचार्ज से संबंधित अध्ययनों के लिए प्रशिक्षित किया जा सके।

A.14 'आशय और उद्देश्य' के आधार पर प्राधिकृत लोगों को आवश्यक सूचनाएं मिल सकें इसके लिए भापअ केंद्र ने एक सिक्योर नेटवर्क एक्सेस प्रणाली का अभिकल्पन और विकास करके इसे स्थापित किया है जिसके तहत यह मानीटरन किया जाता है कि कोई पंजीकृत प्रयोक्ता इस सूचना तंत्र की घ्यूसेज पॉलिसी और प्रोफाइलङ के अनुरूप है या नहीं ।

उच्च स्तर की विशेषज्ञता वाले हमारे बहुत से साथी उच्च प्रौद्योगिकी का प्रयोग करते हुए सुरक्षित और कुशलतापूर्वक कार्य करते हैं। इनमें रिएक्टरों, अपशिष्ट प्रबंधन सुविधाओं, चिकित्सा साइक्लोट्रॉन, आइसोटोप उत्पादन, प्रजनक (ब्रीडर) बीज उत्पादन, इत्यादि की

प्रचालन एवं प्रबंधन गतिविधियां भी शामिल हैं। इस क्षेत्र में कार्य के प्रति हमारे साथियों का समर्पण अनुकरणीय है।

वैज्ञानिक और प्रौद्योगिक कार्यकुशलता के फलस्वरूप हमारे साथियों को प्रतिवर्ष बहुत से सम्मान एवं पुरस्कार प्राप्त होते हैं। परंतु इस वर्ष कहने के लिए कुछ विशेष है। आरएमसी के डॉ. संदीप बसु को चिकित्सा विज्ञान के क्षेत्र में सीएसआईआर शांति स्वरूप भटनागर पुरस्कार प्राप्त हुआ है।

अब मैं भापअ केंद्र की कुछ और उपलब्धियों की चर्चा करना चाहूँगा जो समान रूप से महत्वपूर्ण हैं।

B.1 वर्तमान रिएक्टरों के कालप्रभावन प्रबंधन हेतु रिएक्टर प्रेशर वेसल में वेल्ड की जांच करने के लिए एक वेल्ड निरीक्षण मैनिपुलेटर का निर्माण किया गया और रिएक्टर प्रेशर वेसल वेल्ड की सफाई तथा यूटी परीक्षण करने के लिए तारापुर परमाणु बिजली घर-1 में सफलता पूर्वक स्थापित किया गया।

B.2 रिएक्टर नियंत्रण राड अनुप्रयोग हेतु 8200 समृद्ध बोरोन कार्बाइड पैलेट्स की एक खेप पीएफबीआर को आपूर्ति की गई है।

B.3 तारापुर स्थित उच्च स्तरीय अपशिष्ट हेतु हमारी दूसरी प्रगत कांचीकरण प्रणाली का प्रचालन प्रारंभ हो गया है और बहुत बढ़िया कार्य निष्पादन दे रही है।

B.4 भापअ केंद्र चैनल निरीक्षण प्रणाली का तारापुर परमाणु बिजली घर 3 एवं 4 में कमीशनन हो गया है तथा तारापुर परमाणु बिजली घर-4 के 16 शीतलक चैनलों का ISI कार्य भी किया गया है।

B.5 दाबित भारी पानी रिएक्टर जीवन प्रबंधन के लिए वेट स्क्रैपिंग टूल-III तथा शीतलक चैनलों के लिए सर्कम्फरेंशियल स्क्रैपिंग टूल का विकास किया गया।

B.6 परिष्कृत अप्सरा के लिए ईंधन प्लेटों का संविरचन जनवरी 2012 में आरंभ हुआ। यूरेनियम लोडिंग की आवश्यकताओं की पूर्ति के लिए एक नवीन चूर्ण धातुकी प्रक्रिया का विकास किया गया तथा संविरचन हेतु रोल-बांडिंग तकनीक अपनाई गई।

B.7 प्रगत भारी पानी रिएक्टर एवं 540 मेगावाट दाबित भारी पानी रिएक्टर क्रांतिक सुविधा का प्रचालन विभिन्न प्रयोगों के लिए 52 अवसरों पर किया गया।

B.8 लैंथनम, सीरियम तथा प्रेसियोडिमियम जैसे उच्च शुद्धता वाले विरल मृथ धातुओं का प्रयोग नाभिकीय, स्थायी चुंबकों तथा अन्य उच्च प्रौद्योगिकी क्षेत्रों में किया जाता है। गलित लवण विद्युत अपघटन प्रक्रिया द्वारा उनके क्लोराइड सॉल्ट से इलेक्ट्रॉनिंग द्वारा इन्हें तैयार किया गया।

B.9 प्रयोगशाला स्तर पर सैमेरियम-कोबाल्ट मिश्रधातु तैयार करने के लिए एक रिडक्शन-डिफ्यूजन पद्धति का विकास किया गया।

B.10 इस अवधि के दौरान मनवलाकुरूचि तथा मैसूर में दो और डीएई इमरजेंसी रिस्पॉन्स सेंटरों की स्थापना की गई।

B.11 कन्फेक्शनरी ग्रेड के बड़े दानों वाली और 115 दिन में पकने वाली ट्रांबे-मूंगफली की किस्म टीजी 47(भीमा) वाणिज्यिक फसल उत्पादन हेतु अधिसूचित करके जारी की गई।

B.12 भारतीय पर्यावरणीय विकिरण मॉनीटरन नेटवर्क (IERMON) कार्यक्रम के अधीन खुले मैदान में संस्थापन हेतु सौर ऊर्जा से चलने वाले पर्यावरणीय विकिरण मानीटरन का विस्तार किया गया जिसमें स्थानीय क्षेत्र नेटवर्क (लैन) तथा ऑप्टिकल फाइबर आधारित संचार चैनलों का समावेश किया गया। इस मानीटरन को भारतीय अंतरिक्ष अनुसंधान संगठन (ISRO) द्वारा विकसित स्वचालित मौसम केंद्र के साथ जोड़ा गया।

B-13 Cs कांच स्रोत बनाने के लिए एक मिश्रित क्षार (Li-Na) आधारित गलन्न बोरोसिलिकेट कांच संरूपण का विकास रक्त किरणक अनुप्रयोग के लिए किया गया।

B-14 आरएमसी के लिए विकसित स्पॉट पिकर रोबोट 2D जेल इलेक्ट्रोफोरेसिस में से प्रोटीन स्पॉट का सटीक विश्लेषण करके इसकी पहचान करता है। यह प्रोटीन एक्सप्रेशन का विश्लेषण करने के लिए प्रोटीन को चुनकर उनको ट्रान्सफर करता है । इस प्रकार प्रोटियोमिक्स के क्षेत्र में आंकड़ों की गुणवत्ता बेहतर हो जाती है ।

B-15 कार्गो स्कैन्निंग अनुप्रयोगों के लिए 3/6 MeV द्वैत (डुअल) ऊर्जा संहत इलेक्ट्रॉन लाइनेक एक्स रे स्रोत का विकास कार्य पूरा किया गया।

B-16 बल को परावर्तित करनेवाला एक टेली-रोबोट विकसित किया गया है जो उन्नत विशेषताओं से युक्त नई पीढ़ी की रिमोट हैंडलिंग टेक्नॉलॉजी है।

B-17 चार मास स्पेक्ट्रोमीटरों का विकास करके उपभोक्ताओं के कार्य-स्थलों पर उनका संस्थापन और कमीशनन किया गया। इनमें इंडक्टिविली कपल्ड प्लाज्मा मास स्पेक्ट्रोमीटर, प्रोसेस गैस मास स्पेक्ट्रोमीटर, थर्मल आयोनाइजेशन मास स्पेक्ट्रोमीटर और क्वाड्रपल मास स्पेक्ट्रोमीटर शामिल हैं।

B.18 पहली बार स्वदेश में विकसित डबल क्रिस्टल मोनोक्रोमैटर का कमीशनन किया गया। यह सिंक्रोट्रॉन बीम लाइनों का एक प्रमुख घटक है।

B.19 उच्च दाब और उच्च ताप पर पदार्थों का अध्ययन करने के लिए एक मेगा बार तक दाब के अधीन किसी नमूने के तापक्रम को एक डायमंड एन्विल सेल में लगभग 3000 k तक बढ़ाने के लिए, एक सुविधा (फैसिलिटी) का कमीशनन किया गया।

B.20 350 MHz पर एक उच्च शक्ति वाली रेडियो आवृत्ति प्रणाली का CW सतत तरंग मोड में 67% कुशलता के साथ 60 kW पर अभिकल्पन, विकास और सफल परीक्षण किया गया।

B.21 रेडियो आवृत्ति ट्रांजिस्टरों का प्रयोग करके 350 MHz और 325 MHz दोनों पर ठोस अवस्था एंप्लिफायर टेक्नॉलॉजी का विकास किया जा रहा है। हाल ही में, 325 MHz पर थे एंप्लिफायरों का, 1 और 3.2 kW पॉवर लेवल पर 68% कुशलता के साथ अलग-अलग परीक्षण किया गया।

B.22 लाइन फोकसिंग रिफ्लेक्टरों और ओवरहेड लाइन कैविटी रिसीवरों के क्रम विन्यास पर आधारित प्रगत सौर ऊर्जा-संग्राहक का मुंबई के Institute of Design of Electrical Measuring Instruments (IDEMI) में सफलतापूर्वक कमीशनन किया गया जो 8 kW पावर देता है।

E.1 इस अवधि के दौरान, भापअ केंद्र द्वारा २० प्रौद्योगिकी हस्तांतरण किए गए हैं। हाल ही में हस्तांतरित कुछ प्रौद्योगिकियों में डिजिटल रेडियोथेरेपी, सिम्युलेटर, बनाना टिश्यू कल्चर, शेप मेमरी अलॉय मेकिंग आदि शामिल हैं।

प्रशासन, लेखा, स्वास्थ्य सेवा, अग्निशमन, इंजीनियरी सेवा, सुरक्षा संगठन के हमारे सहकर्मियों से हमें उत्कृष्ट सहयोग प्राप्त हुआ है जिसकी सराहना सबने की है। इनके बिना उपरोक्त कोई भी उपलब्धि प्राप्त नहीं की जा सकती थी।

प्रिय साथियों,

मुझे यह सूचित करते हुए खुशी हो रही है कि हमने इस वर्ष भापअ केंद्र के लिए एक लोगो और ब्रॉशर लॉन्च किया जो हमारे अधिदेश और लक्ष्यों का प्रतीक है। भापअ केंद्र के कार्यक्रम और इसके उत्पाद एवं सेवाएं सामाजिक जरूरतों के सभी महत्वपूर्ण क्षेत्रों पर केन्द्रित रहते हैं जैसे कि खाद्य, जल, ऊर्जा, स्वास्थ्य सेवा, उद्योग, पर्यावरण, शिक्षा और राष्ट्रीय सुरक्षा। इतने कम समय में भापअ केंद्र के प्रत्येक कार्यक्रम की सुर्खियों का उल्लेख कर पाना संभव नहीं है जो 15000 से भी अधिक कर्मचारियों के दल द्वारा सामूहिक रूप से कार्यान्वित किए जाते हैं। यहां तक कि सामरिक क्षेत्र में बड़ी संख्या में कार्यरत हमारे सहकर्मियों के कार्य का उल्लेख तक मैंने नहीं किया है। इसलिए मेरे भाषण में आज जो बातें छुट गई हैं उसका प्रमुख कारण समय की कमी है और उनमें से किसी भी कार्य का महत्व रंचमात्र भी कम है।

हमारे युवा वैज्ञानिकों का अंतर्राष्ट्रीय वैज्ञानिक आयोजनों में भाग लेना उनका कार्य-कौशल निखारने की दृष्टि से अत्यंत महत्वपूर्ण है।

पिछले वर्ष भारत में पहली बार SMiRT-21 का आयोजन किया गया जो नाभिकीय प्रौद्योगिकी के क्षेत्र में एक महत्वपूर्ण अवसर था । इसमें लगभग 600 प्रतिनिधि शामिल हुए और इससे हमारे बहुत से युवा सहकर्मियों को ऐसे अंतर्राष्ट्रीय आयोजन में भाग लेने का मौका मिला।

भापअ केंद्र और परमाणु ऊर्जा विभाग की सभी इकाइयों के बहुत से कार्यक्रम समान हैं। सभी इकाइयों से मेरा अनुरोध है कि हम आपसी तालमेल के साथ लक्ष्यों पर और अधिक ध्यान केंद्रित करें। इन कार्यक्रमों को सफल बनाने के लिए हम एक कदम और आगे बढ़ाकर अथक प्रयास करेंगे।

पिछले चार महीनों में चार बातें हुई हैं जिनसे मैं बहुत खुश हूँ। पी-4 सुविधा और हॉल-8 की सुविधा में काफी लंबे शट डाउन के बाद काम शुरू हो गया है। प्रगत ईंधन संविरचन सुविधा (एएफएफएफ) में दूसरी स्ट्रीम का प्रचालन प्रारंभ हो गया है। मुझे यकीन है कि इससे पीएफबीआर के क्रांतिक होने के लिए ईंधन समय पर उपलब्ध होगा। इन उपलब्धियों के लिए मैं बहुत गौरवान्वित हूँ।

चौथी बात यह हुई है कि केंद्र में अनुशासन को सुधारने में मेरे सहकर्मियों और हमारे एसोसिएशनों ने बहुत सहयोग दिया है। मैं उन सभी को धन्यवाद देता हूँ और इस संबंध में उनसे ऐसे प्रयास जारी रखने की कामना करता हूँ।

साथियों, इस विशेष अवसर पर, हम सब एक बार फिर सत्यनिष्ठापूर्वक अपने आपको इस बात के पुनः समर्पित करें कि हम अपने देश के विशाल जनमानस के बेहतर जीवन के लिए नाभिकीय विज्ञान और टेक्नॉलॉजी के अग्रणी क्षेत्रों में अपनी व्यावसायिक उत्कृष्टता और प्रासंगिकता को बनाए रखेंगे।

आप सबको धन्यवाद। जयहिंद!"

Founder's Day 2012 Address

by
Sekhar Basu
Director, BARC

"Dr Sinha, Chairman, AEC, Senior Members of the DAE Family, Distinguished Invitees, Media representatives, my Colleagues and friends,

I extend a warm welcome to all of you to the Founder's Day functions, commencing with this event here this morning. Today we pay respectful homage to our visionary Founder, Dr Homi Jehangir Bhabha, on his 103rd birth anniversary. We have assembled here for introspecting on our performance and achievements of the past year, and rededicate ourselves to continue to do our best in ensuring maximum benefits to our society from nuclear applications.

To begin with let me tell you about the major performance highlights and achievements of BARC during the last year.

A.1 With KARP and PREFRE-2 in operation, reprocessing programme has seen a turn around and has achieved all time record in capacity utilization. The new reprocessing plant (PREFRE-2) has completed the first full year of operation with outstanding performance both in terms of production and process parameters.

A.2 PHWR pressure tube (PT) ballooning experiments were conducted simulating stratified coolant channel during severe accident scenario. The Pressure Tube heat-up has been found to be arrested after the contact between Pressure Tubes and Calandria Tube, thus establishing moderator as a heat sink for PHWRs.

A.3 Natural and enriched U-6wt% Zr alloy fuel slugs meeting all specifications have been produced by injection casting, and supplied to IGCAR for sodium bonding and test irradiation in FBTR.

A.4 Customized online radon monitors which can operate accurately upto 95% humidity levels, fitted with optional connection for pollutant gas sensors (for CO_2, CO, SO_2 and NO_2) were designed and fabricated indigenously and installed at Turamdih mine. They are utilized for the effective management of mine ventilation system and optimization of radiation dose to the mine workers.

A.5 A technology has been developed for long-term preservation of fresh litchi fruit and demonstrated to farmers in Maharashtra; technology transfer has also taken place.

A.6 Atomic Energy Rules 2012 (Radiation Processing of Food & Allied Products) have been notified by DAE for publication in the Gazette of India. The new rules will allow enhanced commercial exploitation of the food irradiation technology on a wide product range for achieving sanitary and phyto-sanitary standards in international and domestic markets.

A.7 Under rain water harvesting program, harvesting to the tune of around 300 million litres annually has been implemented leading to annual savings of Rs.100 lakhs by effective utilisation of rain water from lake no. 11 in Trombay foot hills.

A.8 A 100 meter long 30 kA hybrid Nb-Ti based Superconducting Cable-in-Conduit-Conductor (CICC) has been fabricated on a 2 meter diameter bobbin at AFD and was despatched to Institute of Plasma Research.

A.9 BARC is a part of Compact Muon Solenoid detector team at CERN – LHC, which discovered experimentally the Higgs Boson. BARC team, in association with BEL, has supplied more than 100 silicon sensors. BARC scientists have been named in the first paper published on the discovery of **Higgs Boson.**

A.10 A large study of newborns from high and normal level natural radiation areas of coastal Kerala was recently completed. The frequency of chromosome aberration and karyotype anomalies between newborns from high and normal radiation levels were similar and no radiation dose related trend was observed.

A.11 Two compact pulse power systems, namely, 400 kev Linear Induction Accelerator and 300 kV compact pulse power system have been developed based on high power magnetic pulse compression switches and exploding wire array switch respectively for high power microwave generation. A 20kV, 40 kJ electromagnetic forming and welding machine was also developed using synchronized spark gap switches for cold welding for industrial and nuclear applications.

A.12 Protein Crystallography beam line, to be used by a large group of Scientists all over India, has been commissioned at Indus-2, RRCAT.

A.13 An Isotope Hydrology Laboratory with advanced equipment has been set-up at the Himalayan Environmental Studies and Conservation Organization, Dehradun to train the local people for spring recharge related studies.

A.14 BARC has designed, developed and deployed the Secure Network Access System to effectively address the requirement of sharing information with "intent and purpose", by monitoring whether a registered user conforms to the 'policy and profile' of usage.

With the high level of expertise a large number of my colleagues carryout work involving high technology in safe and efficient manner. These include O&M activities for reactors, waste management facilities, medical cyclotron, isotope production, breeder seed production, etc. Dedication of my colleagues in this area is exemplary.

Scientific and technological excellence of my colleagues results in receipt of significant number of honours and awards every year. But this year there is something special to tell. Dr. Sandip Basu from RMC has received the CSIR Shanti Swarup Bhatnagar prize in Medical Sciences.

Now, I would touch upon some more achievements at BARC, which are equally important.

B.1 For the ageing management of existing fleet of reactors, a "Weld Inspection Manipulator" has been built for inspection of welds in Reactor Pressure Vessel and deployed successfully in TAPS-1 for cleaning the Reactor Pressure Vessel welds and carrying out UT examination.

B.2 A consignment consisting of 8200 enriched boron carbide pellets has been supplied to PFBR for reactor control rod applications.

B.3 Our second advanced vitrification system for high level waste at Tarapur, has become operational and is giving excellent performance.

B.4 BARC Channel inspection system has been commissioned at TAPS-3&4 and ISI of 16 coolant channels of TAPS-4 carried out.

B.5 For PHWR life management wet scrapping tool-III and circumferential scrapping tool were developed for coolant channels.

B.6 Fabrication of fuel plates for modified APSARA commenced in January 2012. A novel powder metallurgy process developed to meet the required uranium loading and

roll-bonding technique is adopted for fabrication.

B.7 Critical Facility for Advanced Heavy Water Reactor (AHWR) and 540 MWe PHWR was operated on 52 occasions for various experiments.

B.8 High purity rare earth metals such as lanthanum, cerium and praseodymium which find application in nuclear, permanent magnets as well as other high technology areas have been prepared by electrowining from their chloride salts by molten salt electrolysis process.

B.9 A reduction–diffusion method has been developed to prepare Samarium–Cobalt alloy in laboratory scale.

B.10 Two more DAE Emergency Response Centres have been established at Manavalakuruchi and Mysore during this period.

B.11 Confectionery grade large seed Trombay groundnut variety, TG 47 (Bheema), with 115 days maturity was released and notified for commercial cultivation.

B.12 The solar powered Environmental Radiation Monitor for open field installation under IERMON program has been augmented with facilities such as Local Area Network (LAN) and Optical Fibre Based Communication channels. The monitor has been integrated with Automatic Weather Station developed by ISRO.

B.13 A mixed alkali (Li-Na) based low melting borosilicate glass formulation for preparation of Cs glass source has been developed for blood irradiator application.

B.14 Spot Picker Robot developed for RMC accurately analyzes and identifies the protein spots from 2D gel electrophoresis and picks & transfers the proteins for analyzing protein expression, thus enhancing data quality in the field of proteomics.

B.15 For Cargo Scanning applications, the development of a 3/6 MeV Dual Energy Compact Electron Linac X-ray source has been completed.

B.16 A Force Reflecting Tele-robot representing a new generation of remote handling technology with advanced features has been developed.

B.17 Four mass spectrometers were developed, installed and commissioned at user sites. They include Inductively Coupled Plasma Mass Spectrometer, process gas mass spectrometer, Thermal Ionisation Mass Spectrometer and Quadrupole Mass Spectrometer.

B.18 The first indigenously developed Double Crystal Monochromator which is a key component in Synchrotron beam lines has been commissioned.

B.19 To study materials at high pressure and high temperature, a facility to raise temperature upto ~3000 K of sample under pressure upto a mega bar, in a diamond anvil cell has been commissioned.

B.20 A high power RF system at 350 MHz was designed, developed and successfully tested at 60 kW with 67 % efficiency in Continuous Wave mode.

B.21 Solid state amplifier technology development is being done both at 350 MHz and 325 MHz using RF transistors. Recently, two amplifiers at 325 MHz have been tested separately at 1 and 3.2 kW power level with an efficiency of 68 %.

B.22 Advanced Solar Energy Collector based on array of line focusing reflectors and overhead line cavity receivers has been successfully commissioned at IDEMI, Mumbai, giving 8 kW power.

E.1 During this period 20 technologies were transferred by BARC. Some of these recently

transferred technologies include digital radiotherapy simulator, banana tissue culture, shape memory alloy making etc.

Excellent support from my colleagues in administration, accounts, health care, fire services, engineering services, security organizations is appreciated by all. Without these none of the above could have been achieved.

"Dear Colleagues,

I am happy to inform that we launched a logo and Brochure for BARC this year symbolising the spectrum of our mandate and objectives. BARC programmes and deliveries directly address nearly all vital sectors of societal needs, namely, food, water, energy, healthcare, industry, environment, education and national security. It is not possible to cover in a short time all the highlights of each and every programme of BARC, collectively being implemented by a team of over 15,000 employees, leave alone the fact that I have not even made a mention about the work of large numbers of my colleagues in the strategic domain. Thus omissions in my speech here today are mainly due to time constraints and do not undermine the importance of all work left uncovered.

Exposure to international scientific events is an important component in grooming the young scientists.

Last year SMiRT-21, an important event in the field of nuclear technology, was organized for the first time in India. This was attended by around 600 delegates and helped many of our young colleagues to participate in such an international event.

BARC has common programmes with all other units of DAE. My request to all the units is that let us make the interactions more focused and goal oriented. We will walk the extra mile to make these programmes a success.

In the last four months four things have happened, which I am very happy about. The P-4 facility and the facility at Hall-8 have started functioning after very long shut down. Again with the operationalisation of second stream at Advanced Fuel Fabrication Facility (AFFF), I am sure fuel for PFBR criticality will be available in time. I am very proud of these achievements. The fourth thing is the co-operation extended by my colleagues and our associations in improving the discipline in the Centre. I thank all of them and wish continued effort on their part in this regard.

Colleagues, on this very special day, let us once again solemnly rededicate ourselves to continue our professional pursuit of excellence and relevance in the frontier areas of nuclear science and technology for the betterment of life of the large population of our nation.

Thank you all – Jai Hind."

24th DAE All India Essay Writing Contest

The DAE All India Essay Writing Contest in Nuclear Science and Technology for students at the undergraduate level, was started by the Department of Atomic Energy in the year 1989. The 24th All India Essay Contest on Nuclear Science & Technology for regular full time students studying for graduation in any discipline was organised in 2012. The three topics for this year's essays were:

In all, 190 essays were received in English and Hindi from students out of which 36 students were shortlisted to make the oral presentation at DAE.

Thirty two students made their oral presentations, at the Old Yatch Club, DAE.

These students were taken to various DAE facilities that included BARC, Mumbai, BRIT at Vashi, Navi Mumbai, ACTREC and Beam Technology Centre at Kharghar, Navi Mumbai and TAPS, Tarapur.

The Essay Contest winners received prizes from Dr. R.K. Sinha, Chairman, AEC.

The first, second and third prize winners in each topic were as follows:

Topic I: Fast Breeder Reactors for Sustainable Nuclear Power in India

Ms Sahana Mulla Sullamussalam Science College Kerala	B.Sc (Physics) I,	1st Prize
Ms Jinan Haneef C. Sallamussalam Science College Kerala	B.Sc (Physics) III,	2nd Prize
Ms Hiba Haneef C. Sallamussalam Science College Kerala	B.Sc (Physics) III,	3rdPrize

Topic 2: Societal Benefits of Non-Power Applications of Nuclear Science and Technology

Ms Saja Salam M. P. Sullamussalam Science College Kerala	B.Sc (Physics) III,	1st Prize
Mr Varun Varghese Karunya UniversityCoimbatore,	B.Tech II,	2nd Prize
Ms Ashwini Manjunath Bhatt M.E.S, M.M Arts & Science College Sirsi, Karnataka	B.Sc I,	3rd Prize

Topic 3: Lasers, Plasmas and Electron Beams for Cleaner Environment and Sustainability.

Mr Shreyas A. ManipalCollege of Allied Health Sciences Manipal, Karnataka	B Physiotherapy I,	1st Prize
Mr Purohit Sumukh Anil R P Gogate& R V Jogalekar College Ratnagiri, Maharashtra	B.Sc II,	2nd Prize
Ms Chaitra M. Kumbargoudar J S SBanashankar Arts, Commerce & Shantikumar Gubbi Science College Dharwad, Karnataka	B.Sc III,	3rd Prize

The remaining participants were awarded consolation prizes.

Group Photograph of the winners with Dr. R.K. Sinha, Chairman, Atomic Energy Commission and the Coordinators of the Essay Writing Contest

Industrial Safety Awards: 2011

As part of safety promotional activities, the Industrial Hygiene and Safety Section of Radiation Safety Systems Division (RSSD), HS&EG, BARC has introduced an Industrial Safety Award Scheme in the form of Director's Safety Shield on rotation, exclusively for BARC units.

Entries from the various Divisions/Sections/ Units of BARC for the year 2011 were invited under three different categories of units/facilities, namely,

A: Operating Plants

B: R&D Labs and Industrial Units

C: Engineering, Projects and Support Units

A thorough scrutiny of the entries was made and a comparative study of all the entries in each Category was carried out based on the different parameters in respect of Safety Statistics and Safety Management Indicators including that of training and motivational efforts.

Shri S.G. Markandeya, Controller, BARC and Chairman, Industrial Safety Award Scheme Committee and Conventional and Fire Safety Review Committee announced the winning units for the year 2011 as follows.

A: Operating Plants Fabrication	Advanced Fuel Facility (A3F), Tarapur
B: R&D Labs and Industrial Units	FOTIA Facility, Ion Accelerator Development Division(IADD)

Representatives from the respective units received the shield at the hands of Shri Sekhar Basu, Director, BARC. The award comprised one Rotating Shield and a small replica for retention by the respective winning unit.

On behalf of A3F, Tarapur, Dr. Mohd. Afzal, Head, A3F, Shri P.G. Behere, Plant Superintendent, A3F and Dr. Amrit Prakash, Safety Coordinator, A3F, received the shield.

Dr. Pitambar Singh, Head, IADD, Shri S.K. Gupta, Head, FOTIA Section and Shri Arun Agarwal, Safety Coordinator, FOTIA Facility received the shield on behalf of FOTIA Facility, IADD.

Dr. Pitambar Singh, Head, IADD, receiving the Industrial Safety Shield from Shri Sekhar Basu, Director, BARC

Release of the Founder's Day Special Issue of the BARC Newsletter

The Scientific Information Resource Division publishes the Founder's Day Special Issue of the BARC Newsletter every year. It carries the R&D achievements of BARC scientists and engineers for which they received awards and honours at various national and international fora, during the preceding year. As in the last two years, this issue was also published only in the CD format and all the award winners uploaded their papers directly through a special weblink created on the BTS. Out of the 64 award winning papers published in this issue, 36 were DAE Excellence in Science, Engineering and Technology Award papers and the others were Merit Award papers. The Founder's Day Special Issue carried the BARC logo for the first time on its front cover. Shri Sekhar Basu, Director, BARC, released the special issue.

From L-R: Sekhar Basu, Director, BARC, releasing the CD containing the Founder's Day Special Issue of the BARC Newsletter, Dr. R.K. Sinha, Chairman, Atomic Energy Commission and Mr. S.K. Malhotra, Head, PAD, DAE

Founder's Day Guest Lecture (Highlights)

Growth of Neutron Scattering at Trombay: a Tribute to Dr. P.K. Iyengar

by

Dr. B.A. Dasannacharya

Dr. Dasannacharya began his talk with glowing tributes to our Founder, Dr. Homi Jehangir Bhabha on the occasion of Founder's day. Dr. Bhabha, the visionary, laid the foundation for fundamental research in BARC. Dr. Dasannacharya focused on one such area of research: Neutron scattering. He spoke at length on the beginning, the development and the growth of Neutron scattering at BARC and the contributions of several researchers in the field, particularly Dr. P.K. Iyengar.

Sustained neutron research began in BARC in the 1950s under the guidance of Dr. Raja Ramanna, after the 1MeV Cockroft-Walton generator was commissioned at TIFR. Dr. P.K. Iyengar concentrated on neutron scattering and after his initial training on the TIFR accelerator, was sent for further training to Canada under the Nobel Laureate B.N. Brockhouse, who was a pioneer on inelastic scattering. After his return to India, he started work on India's first reactor, Apsara, which had become critical. It was at Apsara that neutron beams were exploited for studying condensed matter. The first automatic diffractometer became operational before 1960. Several papers were published in peer-reviewed journals on neutron beam research.

Later, CIRUS reached criticality on Jan. 16, 1961. Several instruments were installed at CIRUS. By the end of 1961, the neutron scattering group at BARC initiated work on the polarised neutron spectrometer and the crystallography diffractometer, under the stewardship of Dr. Satya Murthy and Dr. Chidambaram respectively. Dr. Dasannacharya described the initial efforts at BARC, to design and develop diffractometers and inelastic scattering

spectrometers, for conducting experiments. At the Second International Conference on inelastic scattering in Canada in 1962, the initial results on lattice vibrations in magnesium, measured on a triple-axis spectrometer, were presented. All the instruments at Apsara and Cirus were upgraded. The Third International Conference on inelastic scattering of Neutrons, held in Mumbai, saw the culmination of efforts at neutron beam research in BARC. Other experiments at BARC were conducted on neutron scattering on liquid Argon, liquid methane, phonon in Magnesium and anharmonic nature of vibrations in NH_4Br. Under the leadership of Dr. Iyengar, BARC became a leading centre in the world on neutron scattering. After 1964, the pace of R&D picked up with the polarized neutron spectrometer becoming fully functional. A computer-based automatic single crystal diffractometer was developed by the Chemical Crystallography group. More sophisticated control systems for constant-Q measurements were built leading to newer and better world class results. A parallel development initiated by Dr. Ramanna and Dr. Iyengar was the Regional Collaboration Agreement in the South East Asian Region, under the aegis of the IAEA. Under this agreement, a diffractometer was installed at the Philippines Atomic Research Centre and several Scientists from Taiwan, Thailand, South Korea, Indonesia and India were trained, which resulted in the foundation of neutron research in the region.

By mid-sixties, the neutron scattering group at Trombay had received international recognition. Pulsed neutron sources were being experimented upon, for better quality neutron experiments. In 1967, a decision was taken to build a critical experimental facility at Trombay, as a precursor to help design a pulsed fast reactor at Kalpakkam. Techniques like small angle scattering, Interferometry, Spin echo spectrometry and the concept of Delta T Window analyzer were introduced and tested at Cirus. In fact, the design of the Delta T Window analyzer was selected for the pulsed neutron source being developed at the Rutherford Appleton Laboratory (SNS) at that time.

The commissioning of Dhruva in 1985 further boosted the capability of neutron beam research by an order of magnitude. The next generation of instruments with improved optics and beam tailoring devices further improved experimental efficiency. A diffractometer of an unconventional design was installed at Dhruva. During this phase, a large number of high Tc superconductors, minerals, magnetic oxides, and alloys, liquids and amorphous materials and some exotic systems were studied using diffractometry, polarized neutron scattering and depolarization, quasi-electron scattering and inelastic scattering.

Under the UGC-DAE Consortium, the facilities at Dhruva were made available to hundreds of scientists from several universities. Thus in a time span of five decades, neutron beam research had been firmly established at BARC.

Dr. Dasannacharya concluded his talk with a tribute to Dr. P.K. Iyengar in the words of Dr. G. Venkataram. "I, like many other first-generation settlers of Trombay, owe you a deep debt on many counts. You have led us, you have inspired us, fought battles for us and also alongside us. You have shown us that we could in fact do things, at a time when many thought that it was not possible. You demonstrated that all it takes is guts and an abiding faith in our selves. This was the message Raman gave to an earlier generation of Scientists in India. We learnt it from you, especially by watching what you yourself did. I am proud to acknowledge my debt publicly and to express my gratitude to you and I do hope that the values you hold dear would be cherished by future generation of scientists here and elsewhere in the country".

DAE (Excellence in Science, Engineering & Technology) Awards 2011

The DAE awards scheme was instituted in the year 2006 to recognize outstanding accomplishments and exceptional achievements of the DAE staff, who are engaged in scientific research, technology development, engineering /project implementation, teaching, healthcare and support services.

These awards are given annually.

The awards for the year 2011 were given on the eve of Founder's Day on October 30, 2012 in BARC. These were presented to the winners by the Chief Guest, Dr. M.R. Srinivasan, Former Chairman, Atomic Energy Commission.

The Awards were in the following categories:

1. Homi Bhabha Science & Technology Awards
2. Scientific & Technical Excellence Awards
3. Young Applied Scientist / Technologist Awards
4. Young Scientist Awards
5. Young Engineer Awards
6. Group Achievement Awards
7. Special Contributions Awards
8. Meritorious Service Awards

I. Homi Bhabha Science & Technology Award carries a Cash award of Rs 5 Lakh, a Citation and a Medal. There were Nine award winners: Seven from BARC and one each from RRCAT and IGCAR. Following were the award winners from BARC:

Dr. P. V. Ananthapadmanabhan, OS L&PTD, BTDG

Dr. Ananthapadmanabhan made innovative and original research contribution that has lead to improved understanding of the phenomenon of plasma spray processes followed by development of plasma technologies for material processing in nuclear fuel cycle applications. He has developed ceramic coatings for protection of critical components that handle uranium and plutonium-bearing alloys. His work on reactive plasma spray processing is adjudged as highly innovative and trend-setting which is evidenced by citation of his papers by many international authors.

Dr. P. V. Ananthapadmanabhan receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan, the Chief Guest and Former Chairman, Atomic Energy Commission

Dr. S. Kannan, SO/H, FCD, RC&IG, BARC

Dr. Kannan made excellent research contribution in field of "Synthetic and Structural Chemistry of Actinide Complexes". He has synthesized a large number of compounds relevant to the separation of uranyl ion from nitric acid medium by using various neutral ligands and characterized them by various spectroscopic and single crystal X-ray diffraction methods. He has established various new modes of bonding for many well known extractants used in actinide partitioning.

Dr. S. Kannan receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan

Dr. D. C. Kar, SO/G, DRHR, DM&AG, BARC

Dr. Kar made outstanding contributions in the indigenous development of equipment for the diagnosis and treatment of cancer patients, especially in the development of our indigenous teletherapy machine 'Bhabhatron'. He has been the lead engineer in the development of the Digital Radiotherapy Simulator for tumor localization, radiotherapy planning and plan verification.

He is also leading the teams for the development of 'Surgical Robotic System' for minimally invasive surgery and 'Digital Mammography System'.

Dr. D.C. Kar receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan

Dr. Archana Sharma, SO/H, APPD, BTDG, BARC

Dr. Archana made excellent contributions for "Technology development in the Pulsed Power Electron Accelerator programme and its utilization for compact high power microwave sources for strategic applications". Her major contributions include the design and development of a 1.5MV, 25kJ Marx generator used in KALI-5000 accelerator, One kilo Joule Marx based repetitive High Power Microwave (HPM) generator, and Linear Induction Accelerator (LIA). Her contributions accelerated and enhanced the pulse power programme for strategic applications in the centre.

Dr. Archana Sharma receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan

Dr. Ram Kumar Singh, OS, RSD, RD&DG, BARC

Dr. Singh has made outstanding contribution in computational and experimental structural mechanics, wave propagation problems in solid and fluid media, fluid-structure interaction, computational fluid dynamics and heat transfer for various thrust areas of the nuclear fuel cycle.

He has addressed important design and safety issues of Indian PHWR / AHWR / BWR in-core components and containments related to structural and thermal hydraulics problems, and also safety evaluation of Indian NPPs for extreme events of tsunamis and earthquakes.

Dr. Ram Kumar Singh receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan

Dr. Amar Sinha, Proj. Manager, N&XPF, PG, BARC

Dr. Amar Sinha, under his able leadership, has made the Purnima neutron generator into a facility which is being extensively used by several research groups. To couple this generator, he has designed a novel, compact and modular subcritical assembly for developing a zero powered ADS system utilizing polyethylene as moderator, beryllium oxide as reflector and natural uranium as fuel. Dr. Sinha has made major contributions in the application of neutron generators for elemental characterization and development of active neutron based methods for the detection of fissile materials.

Dr. Amar Sinha receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan

Dr R. K. Vatsa, SO/H, ChD, CG, BARC

Dr. Vatsa made excellent contribution in the field of "Nanoclusters & Nanomaterials". He has discovered multiple ionization leading to Coulomb explosion at million times lesser laser intensities than previously reported, which is a remarkable breakthrough. He is also leading a group which has made significant contributions in the area of nanomaterials which have potential applications in drug delivery and as luminescent materials. He has to his credit 120 research papers (H index of 17) published in peer reviewed high impact factor international/national journals.

Dr. R.K. Vatsa receiving the Homi Bhabha Science & Technology Award from Dr. M.R. Srinivasan

II. Scientific & Technical Excellence Award carries a Cash award of Rs 1 Lakh, a Citation and a Medal. There were Twenty eight award winners: Twenty one from BARC and two each from IGCAR and RRCAT and three from VECC. Following were the award winners from BARC:

1. Dr. S.N. Achary, SO/F, ChD, CG, BARC
2. Dr. Parag M. Ahmedabadi, SO/F, MSD, MG, BARC
3. Dr. Aniruddha Biswas, SO/G, FMS, MG, BARC
4. Dr. Debabrata Biswas, SO/G, ThPD, MRG, BARC
5. Dr. Anil Krishna Debnath, SO/F, TPD, PG, BARC
6. Dr. Shambhu Nath Jha, SO/G, ASD, PG, BARC
7. Shri Rajeev Keswani, SO/G, MFD, NFG, BARC

8. Dr. Mukesh Kumar, SO/F, SSPD, PG, BARC
9. Shri P. K. Mishra, SO/G, LWRD, RPG, BARC
10. Dr. Paritosh Modak, SO/F, HP&SRPD, PG, BARC
11. Dr.(Smt.) Jyotirmayee Mohanty, SO/F, RPCD, CG, BARC
12. Dr. Sukhendu Nath, SO/F, RPCD, CG, BARC
13. Dr. Lalit Mohan Pant, SO/G, NPD, PG, BARC
14. Dr. (Smt.) Balvinder Kaur Sapra, SO/G, RPAD, HS&EG, BARC
15. Shri Manoj Kumar Sapra, SO/H, RED, RDDG, BARC
16. Shri T. V. Shyam, SO/G, RED , RDDG , BARC
17. Shri Ratnesh Singh Sengar, SO/F, DRHR, DMAG, BARC
18. Shri S. P. Srivastava, SO/H, CDM, DMAG, BARC
19. Dr. T. Sreenivas, Head, MinPD, Hyderabad, BARC
20. Dr. Hari Prasad Upadhyaya, SO/G, RPCD, CG, BARC
21. Shri J.S. Yadav, SO/H, FRD, NRG, BARC.

III. Young Applied Scientist / Technologist Award carries a Cash award of Rs 50,000/-, a Citation and a Medal. There were eight award winners, all from BARC. Following were the award winners:

1. Shri Rajender Kumar Bhatia, SO/E, TPD, PG, BARC
2. Shri Shiv Chandan , SO/E, APPD, BTDG, BARC
3. Shri Yogesh Kashyap, SO/E, N&XPF, PG, BARC
4. Sh. Venkata Pinaka Pani Kondapi, SO/E, Comp.Div., E&IG, BARC
5. Shri Himanshu Kumar Poswal, SO/E, HP&SRPD, PG, BARC
6. Shri S.V.L.S. Rao, SO/E, IADD, PG, BARC & Shri Abhay Kumar, SO/E, CDM, DM&AG, BARC. (Joint Winners)
7. Shri Girdhar Sharma, SO/E, RTD, RD&DG, BARC
8. Shri C.D. Sijoy, SO/E, CAD, E&IG, BARC/Vizag.

IV. Young Scientist Award carries a Cash award of Rs 50,000/-, a Citation and a Medal. There were eight award winners: five from BARC, two from RRCAT and one from IGCAR. Following were the award winners from BARC:

1. Dr. (Mrs.) Swathi Kota, SO/E, MBD, BMG, BARC
2. Dr. Amit Kumar, SO/E (Shri Anil Jain), SSPD, PG, BARC
3. Shri Jitendra Kumar, SO/E, NABTD, BMG, BARC
4. Dr. Jahur Alam Mondal, SO/E, RPCD, CG, BARC
5. Dr. Arup Kumar Pathak, SO/E, TCS, CG, BARC.

V. Young Engineer Award carries a Cash award of Rs 50,000/-, Citation and a Medal. There were twenty seven award winners: twenty four from BARC and one each from VECC, IGCAR and BRIT. Following were the award winners from BARC:

1. Shri Rohit Chandak, SO/E, SSPD, PG, BARC
2. Shri Kinshuk Dasgupta, SO/E, REDS, MG, BARC
3. Shri Kaustubh Gadgil, SO/F, RRMD, RG, BARC
4. Shri Mohananand Jadhav, SO/E, CrTD, ChEG, BARC
5. Shri Kaushal Jha, SO/F, ED&DD, MG, BARC
6. Shri Sachin C. Kadu, SO/E, RPD, RPG, BARC
7. Shri Amit Kumar, SO/F, CnID, E&IG, BARC
8. Shri Subhankar Manna, SO/E, UED, MG, BARC
9. Shri Darshit Mehta, SO/F, WMD, NRG, BARC
10. Dr. Abhishek Mukherjee, SO/E, FRMS, MG, BARC
11. Shri Tarun Patel, SO/D, N&XPF, PG, BARC
12. Shri Avinash D. Patil, SO/E, CDM, DM&AG, BARC
13. Shri Parag A. Punekar, SO/F, RRMD, RG, BARC

14. Shri M. Hari Prasad, SO/F, RSD, RDDG, BARC
15. Shri Abhijit Raha, SO/E, DD, ChEG, BARC
16. Shri Ramakant, SO/E, ED&CD, NRG, BARC
17. Shri Thaduri Ravinder, SO/D, RMP Mysore, BARC
18. Shri Ramesh B. Sabannavar, SO/E LWRD, RPG, BARC
19. Dr. Apu Sarkar, SO/D, MMD, MG, BARC
20. Shri K. Senthil, SO/D, APPD, BTDG, BARC
21. Shri Raj Kumar Singh, SO/D, RED, RDDG, BARC
22. Shri Kumar Vaibhav, SO/E, Comp.Div., E&IG, BARC
23. Shri Shiju Varghese, SO/E RTD, RDDG, BARC
24. Shri B. Vishwanadh, SO/D, MSD, MG, BARC.

VI. Group Achievement Award winners received a medal, a Citation and suitable cash awards for each group commensurate with the group size and its overall achievement. A total number of fifty seven Groups received these awards. Out of these, thirty five groups were from BARC, seven from IGCAR, five from RRCAT, four from NFC, three from BRIT, two from VECC and one from NRB, Kalpakkam.

Following were the Group Leaders from BARC, who received the awards for their groups:

1. Shri D. P. Chakravarthy, Head, APPD BTDG, BARC
2. Dr. V. P. Venugopalan, SO/H, WSCD, CG, BARC
3. Dr. Falguni Roy, Head, Seis. Divn. E&IG, BARC
4. Shri Mohd. Afzal, Head, AFFF, NFG, BARC/ Tarapur
5. Shri S. Pradhan, SO/H, NRB, BARC
6. Shri R. D. Changrani, Ex-CPS, NRB, BARC
7. Shri Amitava Roy, Proj. Director, KNRPC, NRB, BARC/Kalpakkam
8. Shri Mohan M . Kale, Incharge, Central Despatch Section, PD, BARC
9. Dr. Satyendra Gautam, SO/F, FTD, BMG, BARC
10. Dr.(Smt.) Savita Kulkarni, SO/F, RMC/BMG, BARC
11. Dr. A. K. Das, Head, L&PTD, BTDG, BARC
12. Dr. G. Venkateswaran, Ex-Head, ACD, CG, BARC
13. Shri K. T. Shenoy, SO/H, ChED, ChEG & Dr. C.P. Kaushik, SO/H, WMD, NRG, BARC.
14. Shri Hanmanth Rao, Head, ChED, ChEG, BARC
15. Shri C.S.R. Prasad, Ex-Head, ChTD, ChTG, BARC
16. Shri R. L. Suthar , Ex-Head, CDM, DM&AG, BARC
17. Shri S. B. Jawale, Head, CDM, DM&AG, BARC
18. Dr. Anurag Shyam, Head, E&ED, E&IG, BARC/ Vizag
19. Shri Ram Kishan, AD, ESG & Head, TSD, ESG, BARC
20. Dr. Tapas Bandyopadhyay, SO/G, HPD, HS&EG, BARC
21. Shri R. K. Fotedar, OS, FRMS, MG, BARC
22. Shri N. K. Mondal, Ex-SO/H^+, PIED, BARC
23. Shri E. Ramadasan, Ex-OS, PIED, BARC
24. Shri Kailash Agarwal, Dy. GM, NRB, BARC
25. Shri Y. Kulkarni, CPS & Shri V.K. Savarkar, GM, NRB / BARC
26. Shri R. Koul, Head, ApSD, PG, BARC
27. Shri Prahlad V. Joshi, SO/G, RPhD, RC&IG, BARC
28. Shri D. S. Pilkhwal, SO/H, RED, RD&DG, BARC
29. Shri R. J. Patel, Head, RTD, RD&DG, BARC
30. Shri R.R.S. Yadav, Director, RPG, BARC
31. Dr. Ram Kumar Singh, OS, RSD, BARC
32. Shri James Jacob, SO/H RMP/BARC, Mysore
33. Shri T. K. Bera, Director, ChTG BARC/Mysore

34. Shri T. K. Bera, Director, ChTG BARC/Mysore
35. Shri V. Ram Prasad, SO/G, RMP, BARC/ Mysore.

VII. Special Contributions Award carries a cash award of upto Rs. 50,000/-, a Citation and a Medal. There were eighty eight award winners; seventy eight were from BARC, five from DAE, two from AMDER and one each from NFC, RRCAT and VECC. Following were the award winners from BARC:

1. Dr.Tulsi Mukherjee, Director, Chemistry Group
2. Dr. R.M. Tripathi, EAD, HS&EG
3. Dr. P.M. Ravi, HPD, HS&EG
4. Shri A. Ibungohal, PRPD, RG
5. Shri Alok Chaurey, PRPD, RG
6. Shri Avjit Sarkar, MFD, NFG
7. Shri S. S. Gotad, MFD, NFG
8. Shri A.B. Chowdhary, MFD, NFG
9. Shri V. R. Nagvekar, MFD, NFG
10. Shri B.K. Mondal, MFD, NFG
11. Shri K. K. Abdulla, AFD, NFG
12. Shri Amit Sharma, AFD, NFG
13. Shri C. B. Rai, AFD, NFG
14. Shri Surendra Kumar, AFFF, NFG
15. Smt. Geeta P. Vaidya, AFD, NFG
16. Shri D. Das, ED, E&IG
17. Shri P. Lahiri, AD(V), ESG
18. Shri S. V. Kulgod, Comp. Divn., E&IG
19. Shri Vivek Mahadev, Seis. Divn., E&IG
20. Shri Saurabh Garg, EAD, HS&EG
21. Shri A. Ramaiah, IFA, BARC
22. Shri R. N. Pal, ESD(V), ESG
23. Shri C.S.R.C. Murthy, Comp. Divn., E&IG
24. Shri P. M. Kamble, RED, RD&DG
25. Shri D. K. Nathani, RED, RD&DG
26. Shri A. S. Tapase, IAD, RC&IG
27. Shri Kiran J. Jagtap, Director's Office
28. Shri S. M. Pawar, PDD, RC&IG
29. Shri P. Girishkumar, PDD, RC&IG
30. Shri S.P. Roy, PDD, RC&IG
31. Shri T. Sathishkumar, PDD, RC&IG
32. Shri S. G. Sawant, PDD, RC&IG
33. Shri Ramesh G. Nimje, PDD, RC&IG
34. Shri R. D. Sawant, PDD, RC&IG
35. Shri B. T. Jadhav, PDD, RC&IG
36. Dr. K. Krishnan, FCD, RC&IG
37. Dr.(Smt.) M.J. Kulkarni, RCD, RC&IG
38. Shri Nadar S. Dharmraj, PDD, RC&IG
39. Shri M. Ramasubramonian, PDD, RC&IG
40. Shri N.K. Gupta, PDD, RC&IG
41. Shri Kiran G. Kate, PDD, RC&IG
42. Dr. N.D. Dahale, FCD, RC&IG
43. Dr. M. K. Bhide, RCD, RC&IG
44. Shri Priyabrat S. Mishra, Director's Office
45. K. Krishnan Unny, ED&DD, MG
46. Shri K.N. Patel, ED&DD, MG
47. Shri D.T. Nalawade, ED&DD, MG
48. Shri P.P. Sawant, ED&DD, MG
49. Shri N.D. Jadhav, ED&DD, MG
50. Shri N. K. Lawangare, APPD, BTDG
51. Shri Arun Dutta, CDM, DM&AG
52. Shri V. A. Pawar, CDM, DM&AG
53. Shri Mukul Biswas, CDM, DM&AG
54. Shri T. Narayanan, LWRD, RPG
55. Shri P. Goverdhan, LWRD, RPG
56. Shri V. K. Srivastava, DD, ChEG
57. Dr. S. Prabhakar, NDDP & AUGF, ChEG
58. Shri Amit Sur, APD, MG

59. Dr. K. K. Pushpa, RPCD, CG
60. Dr. N. K. Gupta, ThPD, MG
61. Shri G. Kondayya, ThPD, MG
62. Shri U.D. Patil, RRMD, RG
63. Shri Rahul C. Bhangare, EAD, HS&EG
64. Shri Pradyumna Lenka, EAD, HS&EG
65. Shri Alok Ramnivas Tripathi, HPD, HS&EG
66. Shri Sobhana Babu K., RSSD, HS&EG
67. Shri Tej Ram Meena, RSSD, HS&EG
68. Shri Khim Singh, RSSD, HS&EG
69. Shri Suresh Shankar Vichare, RSSD,HS&EG
70. Shri Hari Shankar Patel, RSSD, HS&EG
71. Shri A.M. Govalkar, RSSD, HS&EG
72. Shri S. K. Singh, FRD, NRG
73. Shri B.D. Kshirsagar, PD
74. Shri N.H. Shaikh, Director's Office
75. Shri R.A. Gharat, Director's Office
76. Shri Sachin Yatam, MFD, NFG
77. Shri B.N. Pisal, MFD, NFG
78. Shri M.M. Phondekar, ED&DD, MG.

VIII. Meritorious Service Award carries a cash prize of Rs. 20,000/-, a citation and a medal. There were 25 Award winners. Eighteen were from BARC, 6 from IGCAR and one from DAE Secretariat. Following were the award winners from BARC:

1. Shri S. Aliappa , F/D, MDD, ChTG, BARC
2. Shri N. Aswathappa, T/B, NABTD, BMG, BARC
3. Shri A.N. Bagde, SA/G, ED&DD, MRG, BARC
4. Shri Sadanandan Banarji, Sr.Tech.H, RRMD, RG, BARC
5. Shri V. S. Chandramore, Driver LVD Gr.I, KMG, BARC
6. Shri D.M. Duldhar, F/B, AFD, NFG, BARC
7. Smt. Rajani Jagannath Hadkar, Ex-T/C, HMS, MG, BARC
8. Shri A.D. Kadam, F/C, RPhD, RC&IG, BARC
9. Shri K. Sai Kannan, Accounts Officer, AD, Admn.Group, BARC
10. Shri R.K. Karmakar, F/C, RMD, NFG, BARC
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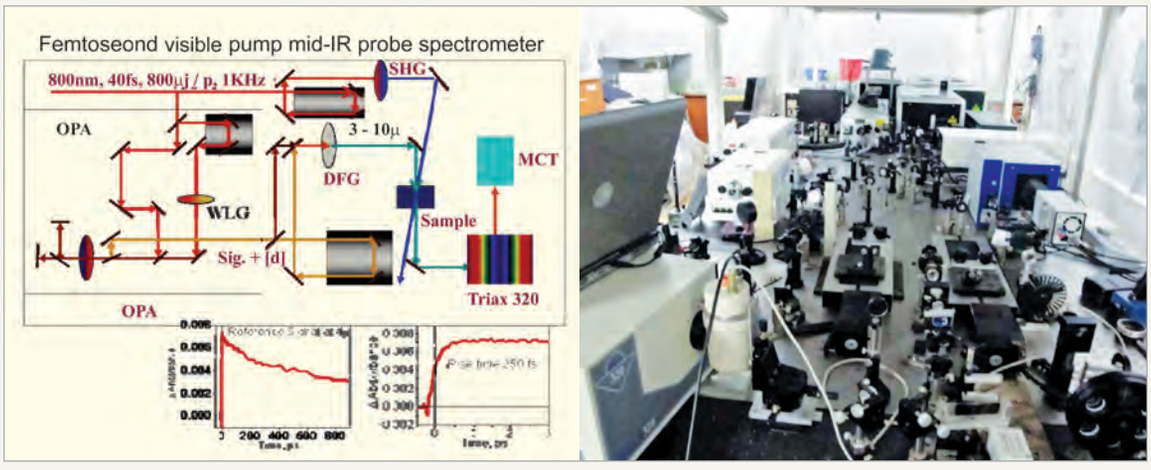
Ultrafast Dynamics Investigations: Development of Femtosecond Time-Resolved Infrared Spectrometer

Chemistry Group

In femtochemistry, studies of physical, chemical, or biological changes are at the fundamental time scale of molecular vibrations, the actual nuclear motions. Normally, electronic transitions are strongly broadened owing to the coupling with the fluctuating solvent and hence relatively featureless due to overlapping of different transitions. Spectral shifting and reshaping caused by solvent reorganization provide an ensemble averaged time-correlation function for liquid motion. Therefore, electronic spectroscopy can provide very limited information regarding the microscopic structure of the transient states and solute-solvent interactions. More insight into the dynamics of molecular Structure and dynamics can be obtained using ultrafast structurally resolving techniques. Ultrafast time-resolved vibrational spectroscopy by probing the fingerprint vibrational modes (1 – 30 mm) has several advantages over the electronic spectroscopy. Vibrational transition can be correlated to specific vibrational motions and hence conclusion can be drawn on specific structural motifs in the molecule. Narrow bandwidth (~10 – 20 cm^{-1}) ensures less overlapping with the neighboring bands and small molecular species can also be probed. Considering the above aspects, a femtosecond time resolved UV pump – IR probe transient absorption spectrometer has recently been developed in Radiation & Photochemistry Division, BARC. This spectrometer uses 400 nm light pulses of 50 fs duration to pump (or excite) the sample. An optical parametric amplifier (OPA) – difference frequency generator (DFG) system coupled to the femtosecond laser system generates the probe pulses of 80 fs in the 1–10 micrometer wavelength region. The probe wavelength can be selected using an IR monochromator. The instrument response has been measured to be about 150 fs. The spectrometer is currently being used for investigation of the dynamics of hydrogen bonds in the excited states of hydrogen-bonded complexes as well as charge transfer dynamics in donor-acceptor molecules.



Development of a 400 keV Radio Frequency Quadrupole

Physics Group

Abstract

A 400 keV RFQ has been designed and built for CW operation at 350 MHz. It has been characterized for RF parameters like frequency and field distribution at low power. The RFQ can be used to generate neutrons using D+D and D+T reaction for ADS experiments.

It has been planned to develop a 400 keV, 1 mA, 4 vane deuteron RFQ operating at 350 MHz for generating high yield of neutrons using D+T reaction. Since RFQ focuses, bunches and accelerates the beam with high transmission, it can replace an existing dc accelerator at PURNIMA neutron generator at BARC, to produce high yield of neutron. In view of this a 400 keV, 1 mA RFQ for D+ beam has been developed. The fabrication has been done at BrahMos Aerospace Triruvananthapuram Ltd (BATL), Trivandrum under an MOU.

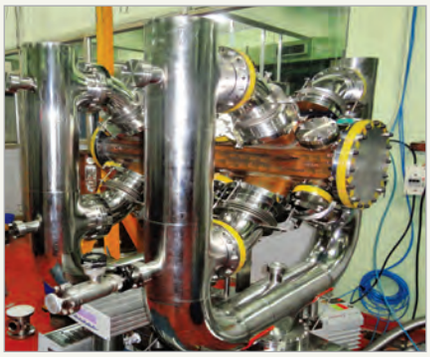


Fig. 1: 400 keV RFQ with its vacuum manifold. It has been tested for vacuum of $4x10^{-6}$ Torr

The RFQ has 16 tuners, 4 vacuum and 2 RF ports. The resonant frequency of 350 MHz was obtained with tuners inserted by 7 mm each. The power is fed using 50 kW RF couplers designed and developed indigenously (Fig. 2). The resonant frequency of the RFQ was tuned to 350 MHz, using bead pull measurement setup (Fig. 3). The

Fig. 2: 50 kW Co-axial RF Coupler.

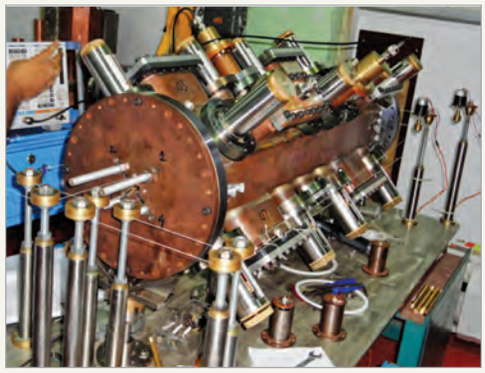


Fig. 3: The 400 keV RFQ with bead pull system

quadrupole field flatness within ±5% and overall dipole contribution was < 4% of the quadrupolar field was achieved.

The dipole modes were about 3.5 MHz away from the fundamental quadrupole mode.

The RFQ is being coupled with the ion source and Low Energy Beam Transport at Van de Graaff labs.

Fig. 4: LEBT test bench with solenoid magnets

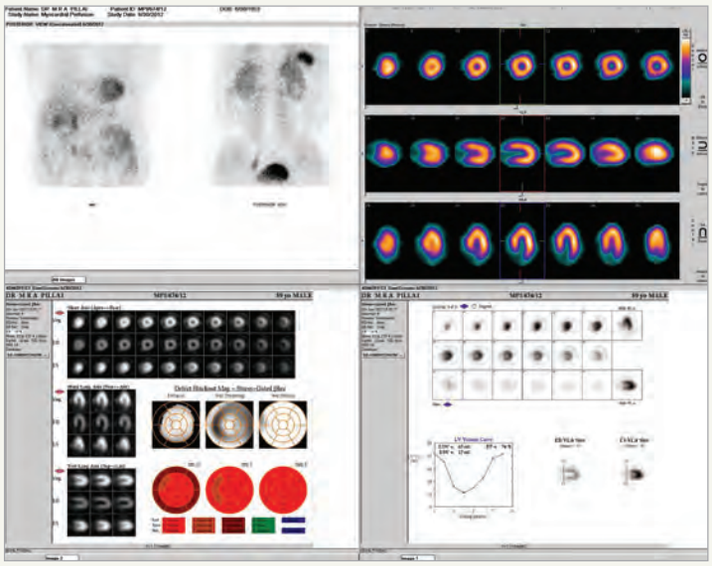
Tetrofosmin Kits for Myocardial Perfusion Imaging

Radiochemistry and Isotope Group

Cardiac diseases are a major cause of human deaths and next only to cancer; however, the mortality rates could be reduced by early diagnosis of the problem. Myocardial perfusion imaging (MPI) using a radiopharmaceutical is a non-invasive technique which provides information on cardiac abnormalities such as coronary artery disease, wall motion defects etc. well ahead of the manifestations of the symptoms. MPI is a simple procedure where the patient takes an injection of the radiopharmaceutical under induced stress followed by imaging under a SPECT camera for about 15-20 min duration.

^{99m}Tc-tetrofosmin is an extensively used radiopharmaceutical for MPI as well as for imaging tumors such as differentiated thyroid carcinoma and breast carcinoma. Radiopharmaceuticals Division has developed a lyophilized kit for the formulation of ^{99m}Tc-tetrofosmin using generator eluted pertechnetate ($Na^{99m}TcO_4$). The active pharmaceutical ingredient (API) of the kit, tetrofosmin, was synthesized by using basic chemical ingredients and in-house developed glass apparatus which allowed handling of the pyrophoric intermediates under inert atmosphere.

Several batches of tetrofosmin kits were prepared and subjected to extensive physico-chemical tests as well as biological tests to ensure pharmaceutical purity to confirm the safety of the kit for use in humans. Biological evaluation of ^{99m}Tc-tetrofosmin was tested in Wistar rats to establish its efficacy to target myocardium. The tetrofosmin kits yielded sterile ^{99m}Tc-tetrofosmin with high degree of radiochemical purity as estimated by HPLC. The formulation of ^{99m}Tc-tetrofosmin using the kits is done by addition of upto 200 mCi of generator eluted pertechnetate to the kit followed by incubation at room temperature for 20 minutes. Based on the data collected from multiple batches a regulatory approval was obtained from the Radiopharmaceuticals Committee (RPC) for large scale manufacture and supply.



Typical images of a normal myocardium obtained with ^{99m}Tc-tetrofosmin kit developed by BARC

Unveiling the Mechanism of Extreme Radiation Resistance in *Deinococcus radiodurans* by Comparative Proteomics

Bio-Medical Group

D. radiodurans, an extremophilic microbe (Fig 1A), is listed in the *Guinness Book of World Records* as '*the world's toughest bacterium*' for its unprecedented resistance to all DNA damaging agents including ionizing radiation (> 6kGy). It possesses extraordinary DNA repair and oxidative stress alleviation capabilities. Comparative proteomic approach was used to elucidate mechanism underlying its radiation resistance.

Following exposure to 6kGy gamma irradiation, *D. radiodurans* undertakes an exhaustive repair of all radiation damaged biomolecules during the post-irradiation recovery (PIR). Cellular proteins harvested from control and irradiated cells in different stages of PIR were resolved by 2-dimensional protein electrophoresis (2-DE). Throughout the initial 4h of growth arrest, about 40 proteins displayed enhanced or *de novo* expression in the irradiated cells as compared to the control cells in the same stage of PIR (Fig. 1B). These proteins were processed by Matrix Assisted Laser Desorption Ionization – Time of Flight/Time of Flight Mass Spectrometry (MALDI-ToF/ToF-MS) to obtain a peptide mass fingerprint (PMF). Comparison of PMF with MASCOT database (Matrix Science, UK) revealed the identity of various cellular proteins.

The irradiated cells displayed increased abundance of DNA repair and oxidative stress alleviation proteins. A dynamic pattern of appearance and disappearance of these proteins during PIR revealed the chronology of multistep DNA repair process (Fig. 1C) comprising of (1) DNA template preservation, (2) utilization of preserved DNA templates to build exhaustive scaffold through strand annealing and non-homologous end joining, and (3) final touch up by high fidelity homologous recombination to regain intact chromosomes with correct DNA sequence (Basu B. and Apte SK., 2012, *Mol. Cell. Proteomics*, 11, 1-15). Comparative proteomics is a vital tool for capturing global cellular changes in living organisms to gain functional insights into stress response, metal/drug resistance, host-pathogen interactions, cancer and other biological phenomena.

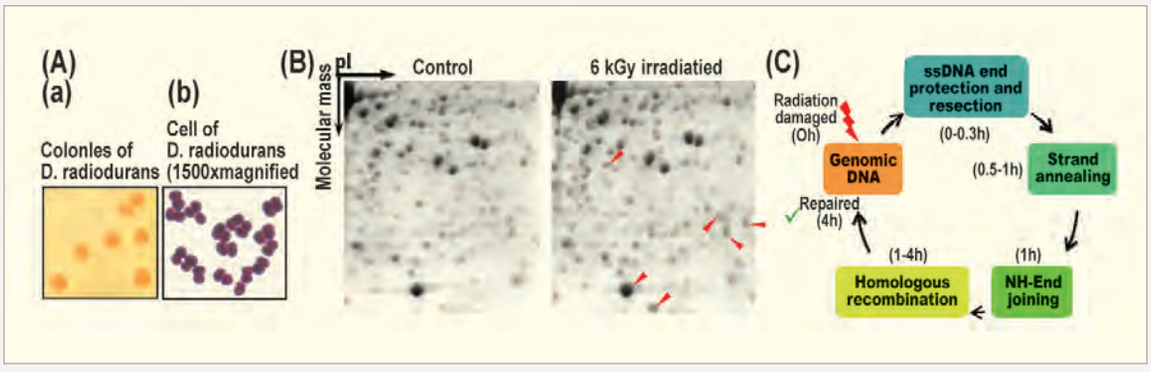


Fig. 1: Gamma irradiation resistance in *D. radiodurans*. (A) (a) Colonies of *D. radiodurans* and (b) *D. radiodurans* observed by light microscopy. (B) Cellular 2D protein profiles of control and 6kGy irradiated *D. radiodurans* after 1h of PIR. Red arrows denote induced proteins. (C) Schematic representation of the multistep DNA repair in *D. radiodurans*.

Genetic Analysis of Type 2 Diabetes

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Abstract

Diabetes has intrigued geneticists for a long time, mainly due to variability in onset and familial clustering. In the current study, we have tried to identify the role of few candidate genes and their variations in causing type 2 Diabetes. We have used the family-based method to study the transmission and inheritance of genes in diabetic families. Single affected-parent and the proband with siblings where primarily taken for this study. We found that INSR and GLUT4 have emerged as the main genes associated with T2DM and risk factors in our study population. In addition, results also show that GLUT4 plays a major role in the family history inheritance pattern.

Introduction

Diabetes Mellitus (DM) is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The basis of the abnormalities in carbohydrate, fat, and protein metabolism in diabetes is deficient action of insulin on target tissues. Deficient insulin action results from inadequate insulin secretion and/or diminished tissue responses to insulin at one or more points in the complex pathways of hormone action. Impairment of insulin secretion and defects in insulin action frequently coexist in the same patient, and it is often unclear which abnormality is the primary cause of the hyperglycemia. (ADA position statement, 2010).

Diabetes has intrigued geneticists for a long time, mainly due to variability in onset and familial clustering. Diabetes can lead to both macrovascular and microvascular complications. Myocardial infarction, renal failure and stroke happen to be few examples of the problems. Diabetes Mellitus (DM) can be classified into Type 1, Type 2, Gestational Diabetes Mellitus (GDM) and other specific types. Type 1 is caused by complete destruction of insulin producing cells by various causes (mostly immune mediated). Type 2 Diabetes may range from predominantly insulin resistance with relative insulin deficiency to a predominantly secretory defect with insulin resistance (ADA position statement, 2010). The other types include monogenic forms of diabetes like maturity onset diabetes of young (MODY 1 - 11) caused by various genes *(HNF4A, GCK, HNF1A, IPF1, TCF2, NEUROD1, KLF11, CEL, PAX4, INS and BLK respectively)*. In addition to above, defects in insulin action, diseases of pancreas, endocrinopathies and factors like chemicals, drug or virus (ADA position statement, 2010) also cause some minor forms of diabetes. Gestational diabetes is major health concern in pregnant women; although mostly transient, it increases the risk of getting diabetes at a later age.

The genetic cause of MODY is fairly well understood and Type 1 Diabetes Mellitus (T1DM) has been known to be immune mediated, but Type 2 Diabetes Mellitus (T2DM) is an enigma. Genetic studies of T1DM have unraveled the role of HLA genes and identified them as the major contributors for T1DM (Todd. JA. et. al. 1987, Herr.M et. al 2000). T2DM is a polygenic disease with complex inheritance patterns. As the environmental factors play an equal role in the development of the disease, the T2DM is also known as multifactorial disease. T1DM form less than ~5% of the diabetes cases, while the major chunk about 92-95% is T2DM. Our study focuses on the T2DM and looks into the genes and variations observed in them. Although, various risk factors

for diabetes differ between ethnic populations, the risk conferred by a family history of diabetes is most prominent. The cases of T2DM show 70% concordance in twins and 40% occurrence when one parent is diabetic or 70% occurrence when both parents are diabetic and furthermore, a marked maternal influence was also observed. All these factors point to underlying genetic causes of T2DM (Ridderstråle and Groop, 2009). Candidate gene studies and GWAS (Genome Wide Association Studies) had thrown up at least eighteen different genes using the case-control approach (Saxena et. al 2007, Zeggini et.al 2007 and Scott. et .al 2007) with very little work being done using Family based approach.

The diagnosis and prognosis of diabetes is quite good and only a fraction of cases goes un-noticed until a major episode like stroke or myocardial infarction. Though the presence of family history of Diabetes increases the risk, it is a challenge to identify, at the genetic level, individuals who are at risk. If the individuals at risk are identified at a younger age, medical intervention can help them lead a healthier and possibly disease-free life and avoid health complications, which may be debilitating and fatal.

Indian studies on diabetes have been few and most of them are case-control studies. We have tried to identify the role of candidate genes in T2DM in our population using extended families. The advantage of family based approach is that it takes care of the population stratification caused by multiple ethnicities. The study model is also powerful to pick maternal and epigenetic effects, which is not possible to be detected by case control approach and keeps the sample size smaller when large families are used. We have used large families rather than trios *(parents and one child)* for this study. The extended sibs (more than one child in a family) increase the confidence of the study especially when T2DM is a late-onset disease.

We selected genes from Insulin pathway, modifiers of Insulin action and secretion and candidate genes reported by the GWAS studies. The present study looks into the role of single nucleotide polymorphisms (SNPs) at these genes as a factor influencing diabetes. It also investigates the underlying genetic predisposition to the common risk factors in T2DM. The transmission and inheritance of these have been studied in the context of susceptibility to type 2 Diabetes and risk factors.

Materials and Methods

The current study uses candidate gene approach, selected from 1) Insulin pathway- Insulin receptors(INSR), Insulin receptor substrate 1(IRS1), Glucose transporter 4 (GLUT4 or SLC2A4) 2) Modifiers of Insulin action or secretion- Hepatocyte nuclear factor 4 alpha (HNF4a), Calpain 10 (CAPN10) and Transcription factor 7-like 2 (TCF7L2) 3) Genes identified from GWAS studies in other populations- Protein kinase N2 (PKN2), Proliferator activated receptor gamma (PPARG), Insulin-like growth factor 2 binding protein 2 (IFG2BP2), TWO from INTERGENIC REGION, CDK5 regulatory subunit-associated protein 1-like 1(CDKAL1), Solute carrier family 30 (zinc transporter), member 8 (SLC30A8), Cyclin-dependent kinase inhibitor-2A/2B (CDKN2A /B), Hematopoietically Expressed Homeobox (HHEX), Transcription factor 7-like 2 (TCF7L2), Potassium inwardly-rectifying channel, subfamily J, member 11 (KCNJ11) and Fat mass and obesity associated(FTO).

The subjects were chosen from the employees and their family members of our institution, who are catered for their entire life by BARC hospital. The subjects were chosen based on inclusion and exclusion criteria. About 5000 individuals were interviewed and finally 79 families were recruited. The data on lifestyle parameters including ethnicity, food habits, activity levels, family history of DM and complication resulting from DM, anthropometric parameters and biochemical characteristics were collected and stored in a database.

Biochemical parameters like fasting and post prandial glucose, cholesterol, triglycerides, glycated

hemoglobin and hormones like insulin- c-peptide and thyroid hormones and cortisol were estimated in the laboratory attached to our hospital.

Alleles can be bi-allelic, tri-allelic or multi-allelic. Bi-allelic refers to the presence of any two different nucleotides at a given position in the DNA sequence eg- A/T, G/A etc.. triallelic means any of the three different alleles can be present at the given position.eg- A/G/C , T/G/C etc, while mutli-allelic refers to the possibility that any of the four nucleotides can occupy the postion in the DNA sequence . SNPs from the selected genes were identified from exons, splice sites, untranslated regions and few introns. The dbSNP database at the NCBI was the source of the information on SNPs. Initially ~100 SNPs were selected and after the first phase of genotyping on a group of reference samples, the list was pruned to 52 SNPs based on presence of polymorphism in our population. All but one SNP were bi-allelic with one SNP rs3212210 from HNF4a being tri-allelic.

Genotyping was done on Sequenom platform (MALDI-TOF), and data analyzed by PLINK, a whole genome association analysis toolset, Family-Based Association Test Toolkit (FBAT), Power-Based Association Test Toolkit (PBAT) and trial version of SVS 7.0 suite of Golden helix software, which is PBAT with a graphical user interface and other genetic analysis tools for family or population based studies. The data was curated for genotyping errors. This software analyses the inheritance and transmission of variation from affected parent to both unaffected and affected progeny. In addition to the PBAT analysis (family based analysis), basic allelic tests (analyzing all individuals as cases and unaffected controls) and haplotype analysis were also conducted on the data sets.

Results

Epidemiological parameters

Three hundred and forty three individuals from seventy nine families were collected for the study with average of 4.34 members (range 3 - 14). The population was dominated by the local Maharashtrian ethnic population at ~58%, while other major groups were from the states of Kerala, UP and Tamilnadu. Mean age of the subjects was 55 yrs. Onset age peaked at 41-50 age groups for men and women showed a steady plateau from 41 -80 years of age with slight increase from 61-80 years. Majority of the diabetic were on oral hypoglycaemic drugs. Almost 60% of diabetic individuals had a disease duration ranging from 1-12 years.

About 41 % males and 36% of females in the families had diabetes, with ~40% of diabetics with hypertension ($p<0.05$). The presence of diabetes increases the risk of presence of hypertension (HTN) among both males and females. The family history showed that more people reported mother affected (43.3%) as compared to father affected (39.3%). The frequencies of mother affected were higher compared to father affected in both normoglycemic and diabetic individuals ($p<0.001$).This indicates a slight maternal effect, which had also been noted in an earlier epidemiological study conducted in the laboratory.

The BMI analysis showed that ~82% of female diabetic members were in overweight to obese category compared to ~70% female normoglycemic members ($p=0.038$). There was no difference in the distribution among male diabetic members and male normoglycemic members.

Genetics studies

Generally the basic genotype tests, taking the whole families as cases or controls, agreed with the PBAT analysis. The significant alleles from the basic tests were also many a times the significant allele from the PBAT analysis. The heritability factor for any SNP did not exceed 0.05 in our study, showing smaller effects of the SNPs studied in our population.

The following table shows few important SNPs and their association with Diabetes in different models.

In the current study rs1051651 and rs1799817 from INSR is significantly associated with T2DM. The

Table1: Summary of epidemiological data. (Parameters with * mark are significant at $p<0.05$ level) HWR-Height waist ratio, BMI- Body Mass Index, WHR- Waist to Hip ratio, FBS- Fasting blood sugar, PP-Post Prandial sugar, Gly Hb-Glycosylated Hemoglobin , Chol- Cholesterol, LDL- low density lipoproteins, HDL- High density lipoproteins, Trigly-Triglycerides.

	Normoglycemic Family membersDiabetic Family Members			
	Male	Female	Male	Female
HWR	0.54(±0.06)*	0.58(±0.08)*	0.57(±0.06)	0.61(±0.06)
BMI	24.5(±4.1)	25.6(±4.5)*	25.5(±3.6)	27.1(±4.2)
WHR	0.92(±0.10)*	0.88(±0.08)	0.96(±0.06)	0.89(±0.06)
FBS(in mg/dl)	87.6(±11.5)	90.1(±11.6)	149.9(±49.1)	148.4(±46.6)
PP(in mg/dl)	91.7(±27.1)	99.4(±28.5)	215.0(±79.3)	197.0(±69.1)
Gly_Hb(%)	7.1(±0.9)*	7.3(±1.2)*	8.7(±1.8)	8.9(±1.6)
Chol(in mg/dl)	182.8(±40.6)	190.5(±40.3)	175.1(±36.1)	188.8(±44.7)
LDL(in mg/dl)	115.3(±30.7)	121.2(±32.8)	108.1(±30.6)	117.6(±33.1)
HDL(in mg/dl)	41.1(±7.1)	46.4(±7.7)	41.1(±7.5)	45.4(±8.7)
Trigly (in mg/dl)	128.0(±78.9)	103.2(±47.4)*	150.1(±86.3)	133.3(±64.0)

Table 2: Consolidated results of PBAT analysis for Diabetes. Allele indicated is the 'at risk' allele . Additive model: increased risk when two alleles are inherited compared to one allele. Dominant model: similar risk when one or two at risk alleles inherited.

SNPid	GENE	Allele	GENETIC MODEL	P value
rs1051651	INSR	C	ADDITIVE	0.01
rs1799817	INSR	C	DOMINANT	0.02
rs5219	KCNJ11	T	ADDITIVE	0.03
rs5418	SLC2A4	G	ADDITIVE	0.01
rs5435	SLC2A4	C	Heterozygous	0.001

Table 3: Association of SNPs from the SLC2A4 genes with T2DM and the risk phenotypes.(UTR- untranslated region, BMI-body mass index, DM- Diabetes Mellitus, HTN- hypertension, parental- role in parental history of T2DM, WHtR- Waist to Height Ratio, trigly- triglycerides).

rs5418(5'-UTR)	rs5435(coding synonymous)	rs8082645(3'-UTR)
BMI	BMI	BMI
DM	DM	HTN
HTN	HTN	parental
parental	parental	WHtR
WHtR	Trigly WHtR	

alleles C/T in rs1799817 cause a synonymous change (Asparagine). The SNP rs1051651 is in the non-coding region and in the 3'-UTR region.

In the current study, SLC2A4 has emerged as the leading gene in terms of effect on T2DM and the risk phenotypes.

One of the interesting results of the study was the differential transmission of alleles against the background of parental history. The major allele of SNP rs5435 was over transmitted in the case of a positive paternal history, while major allele of rs5418 and rs8082645 was over transmitted in positive

maternal history. This suggests a parent specific effect of certain alleles from GLUT4. GLUT4 is the insulin responsive glucose transporter active in muscles and adipose tissues. Muscles and adipose tissues are the major sites where glucose utilization takes place. The association of certain alleles of GLUT4 and INSR in the T2DM is certainly very interesting and their role needs a detailed study.

Conclusion

GLUT4 seems to play a major role in familial diabetes in our population. Some of these genes were part of large genome wide studies and had shown association in Caucasian (UK and Finland) population, though the same genes did not show any association with Han Chinese studies. A different set of genes showed the association in the Han Chinese population. Many SNPs seem to be involved in interaction between diabetes and other peripheral phenotypes. The SNPs from KCNJ11, INSR, HHEX, PKN2 and CDKAL1 emerging to be most likely candidates to influence the phenotypes. There seems to be increased maternal transmission, suggesting epigenetic or sex influenced effects. Some authors have also reported increased maternal transmission (Wada et. al, 2006). The Allele frequencies from our study show that the Indian population seems to share more similarity with Caucasian population genotypes than the Han Chinese, Japanese and African population. Similarly, few genes, which are significantly associated in Caucasians, are also involved in our population. Still majority of them do not match. Haplotype analysis did not show any major block, two blocks of two SNPs showed some correlation. Haplotype association study needs to have a larger population and SNPs with larger minor allele frequency.

A larger study with about 2500 diabetic cases and about equal number of controls would help in confirming the findings in our population. SNP discovery in the complete insulin pathway genes and other genes in our population can identify susceptible genes and their variation. In fact, the underlying mechanism of all the genes, which have been associated in diabetes, is yet to be elucidated. Haplotype association study needs to have a larger population. A genome wide study needs to be conducted in our population to identify susceptible genes and their variations. Though few genes from other studies match our association studies, our population specific genes are yet to be uncovered.

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Advanced Research on Master Curve for Safety Assessment of Reactor Pressure Vessel

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Introduction

Fracture toughness is the key input for designing, monitoring and residual life assessment of Reactor Pressure Vessel (RPV) components. The value of fracture toughness is influenced by geometry (specimen/component), size (b, a/w), environment (temperature, irradiation, corrosion) and loading (strain rate). One major issue is the transferability of the fracture toughness value obtained experimentally from specimen to real application level and another issue to track the change in the value through the life due to environmental causes. A lot of empirical and theoretical correlations to capture the geometry, size and loading rate dependence of fracture toughness are available and already standardized into code. There are many reasons (low temperature, neutron irradiation and corrosion) for which material loses its ductility and thus degraded. Therefore a key input into the assessment of RPV integrity is the knowledge on variation of the material fracture toughness with temperature and degree of irradiation. In last few decades research has been focused to characterize the temperature dependence of fracture toughness and to extend the methodology to assess the material degradation (embrittlement) by irradiation.

Charpy test data at different temperatures (Fig.1) reveals that toughness of ferritic steels and others begins to decrease with lowering of temperature and become almost brittle at very low temperature, exhibiting a transition range of temperature with in which the behavior of the material shifts from ductile to brittle. This is termed as ductile to brittle transition temperature range (DBTT). In the transition range the value of fracture toughness is not only temperature dependent but also scattered even at a fixed temperature (Fig.2).

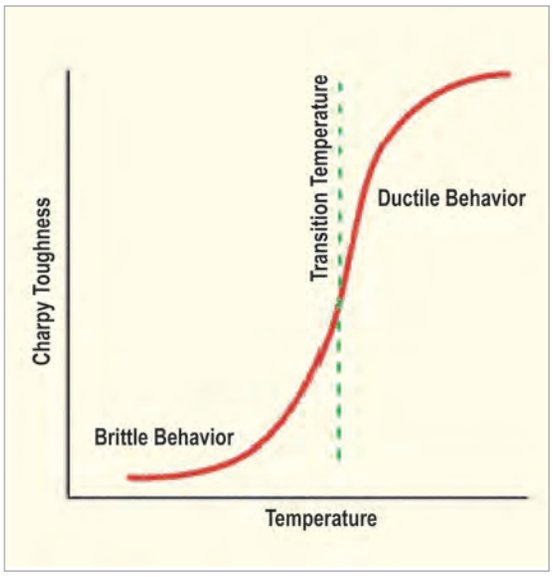

Fig.1: Typical CVN energy variation

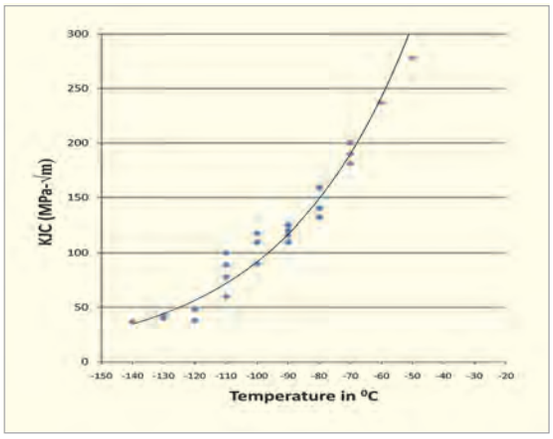

Fig.2: Scatter of fracture toughness data in transition range

The temperature dependent property of fracture toughness, for cleavage and ductile fracture, is widely used to analyze the structural integrity of components. Such an analysis provide both, sufficient safeties for the component and the reduction of conservatism for estimation of the critical states. At low temperatures, steel is brittle and fails by cleavage. At high temperatures, the material is ductile and fails by microvoid coalescence. In the transition region between ductile and brittle behaviour, both micro-mechanisms of fracture can occur in the same specimen. In transition zone the analyses use probability distribution functions to describe the fracture toughness data which vary from fully cleavage at lower temperatures to fully ductile at higher temperatures.

Assessment of degree of embrittlement (reduction in value of fracture toughness) plays the most crucial role in advanced structural integrity assessment. This embrittlement may be caused due to low temperature as well as by irradiation, change in microstructure or corrosion. The components in nuclear power plants which are subjected to irradiation or any other components facing low temperature are required to be continuously monitored for assessment of loss of ductility during the operational life.

Therefore a comprehensive methodology to describe the fracture toughness of structural steels encompassing the ductile, ductile to brittle transition (DBT) and completely brittle fracture influenced by temperature, irradiation and other causes has been attempted to be developed during the last few decades.

Transition-Temperature Curve and Nil Ductility Temperature (NDT)

The notched-bar Charpy impact tests are conducted over a range of temperatures to generate Transition-Temperature Curve [1] so that the temperature at which the ductile-to-brittle transition takes place can be determined. A well-defined criterion is to base the transition temperature on the temperature at which the fracture becomes 100 percent cleavage. This point is known as nil ductility transition temperature (NDTT). The NDTT is the temperature at which fracture initiates with essentially no prior plastic deformation. Below the NDTT, the probability of ductile fracture is negligible. Later another reference temperature for nil ductility for transition (RT_{NDT}) was defined as the temperature at which the Charpy Impact energy for failure is observed to be equal to 41J. If a material is embrittled then this reference temperature will be increased and the shift in this temperature can be a measure of degree of embrilltlement. ASME Code K_{IC} curve characterizing for static crack initiation and the K_{ID} / K_{IA} / K_{IR} curve for dynamic crack arrest are based upon an approach that utilizes a material normalizing and indexing parameter, RT_{NDT}. By establishing appropriate RT_{NDT}, the K_{IC} curve can be positioned appropriately for use in RPV integrity assessment. The appropriate position of K_{IC} curve for irradiated material can be adjusted by finding RT_{NDT} of irradiated material. The shift in RT_{NDT} is the measure of loss of ductility due to irradiation. The adjusted K_{IC} curve is to be considered for structural integrity analysis at this stage. However, the ASME Code fracture toughness curves, K_{IC} and K_{IR}, are lower bound curves that are not based on probability assessment and hence very much conservative.

Later, Wallin developed (adopted in ASTM E 1921-02) [2] specifically to provide a measurement of fracture toughness transition temperature (T_0) that properly accounts for specimen size, strain rate (over a range of nearly static loading rates), and specimen notch acuity (fatigue pre-cracked). This Master Curve procedure to determine T_0 provides a more reliable prediction of actual material behavior. The master curve defines both the variation of the median value of fracture toughness with temperature and the scatter of fracture toughness about this median value. The master curve together with an ASTM E1921[3] reference temperature (T_0) value defines the complete transition fracture toughness curve in a manner appropriate for use in

both probabilistic and deterministic analysis. In the master curve method, a fracture toughness curve is determined by a single parameter that establishes the position of the master curve on temperature scale. This parameter is termed as T_0 and is defined as the temperature at which the median fracture toughness for 1T–CT fracture toughness specimen equals 100 MPa$\sqrt{m}$ [4]. The master curve method is also used to construct a bounding curve on the fracture toughness. Typically a bounding curve with a 95% degree of confidence is used as lower bound on the fracture toughness values. This implies that 95% of all fracture measurements should fall above the confidence/ tolerance bound.

Wallin [5,6] described the cleavage fracture toughness behaviour in the lower ductile-to-brittle transition (DBT) range of ferritic steels. Using the J-integral-based cleavage fracture toughness, K_{Jc}, it was demonstrated on many materials that the temperature dependence of the median fracture toughness has a unique shape, the so-called ''Master Curve'' (MC), which can be adjusted with a reference temperature T_0. The MC approach postulates four assumptions:

- the statistical analysis using a three-parameter Weibull distribution,
- the statistically derived specimen size adjustment,
- a unified temperature dependence and
- material homogeneity at the macroscopic level.

In this analysis, the scatter of fracture toughness value in DBTT is explained assuming that cleavage fracture in the transition range is initiated at the randomly distributed nucleation sites in the material matrix and followed by crack propagation. The factors (temperature, thickness, loading rate, irradiation) influencing this phenomenon make the fracture to be probabilistic. The fracture toughness is not a definite value rather for each value of fracture toughness there is a value of probability of failure. It is derived theoretically and verified experimentally that the scatter is best fitted by Weibull characteristics.

The basis of the master curve approach is a three parameter Weibull model which the relationship between K_{JC} and the cumulative probability failure P_f

$$P_f = 1 - \exp\left[-\left(\frac{K_{JC} - K_{min}}{K_0 - K_{min}}\right)^4\right]$$

where, $K_{JC'} = \sqrt{\frac{J_C E}{1-\nu^2}}$

where K_{JC} is the fracture toughness corresponding to P_f, K_0 is the scale factor of Weibull distribution and is the value of fracture toughness corresponding to 63.2% cumulative failure probability and K_{min} is the lower bound fracture toughness.

From experimental and theoretical observations it appears that for all ferritic steels, the value of Weibull modulus is best fit at 4 and the value of K_{min} can be taken as 30 MPa"m. Therefore, for a particular steel the value of K_{JC} is to be estimated experimentally from J-R curve test. The distribution of fracture toughness value at a particular temperature is completely available by the values of K_{JC}. Using maximum likely-hood principle and Weibull distribution the value of K_0 is determined from the following equation:

$$K_0 = \left[\sum_{i=1}^{N} \frac{\left(K_{JC(i)} - K_{min}\right)^4}{N}\right]^{1/4} + K_{min},$$

where $K_{JC(i)}$s are determined from experiments with different specimens and N must be at least six . Then $K_{JC(med)}$ is computed by the equation, $K_{JC(med)} = K_{min} + (K_0 - K_{min})(\ln 2)^{1/4}$. In this way $K_{JC(med)}$ can be determined at different test temperatures. The variation of $K_{JC(med)}$ with temperature is observed to be best fitted exponentially as

$$K_{JC(med)} = 30 + 70 \cdot \exp\left[0.019 \cdot (T - T_0)\right]$$

Where T_0 is a reference temperature at which the median fracture toughness of 1T–CT fracture toughness specimen is 100 MPa$\sqrt{m}$. For specimens

with other thicknesses the following equation is used to compute 1T–CT equivalent fracture toughness

$$K_{JC(1T)} = K_{\min} + \left[K_{JC(X)} - K_{\min}\right]\left(\frac{B_X}{B_{1T}}\right)^{1/4}$$

Once the value of $K_{JC(med)}$ is known from the experiments at a single temperature T , the value of T_0 can be obtained from the equation. Then the $K_{JC(med)}$ vs. temperature (T) curve for the material can be plotted from a single temperature test results. It is observed that the value of $K_{JC(med)}$ varies with temperature in such a way that the value of T_0 does not alter for a particular material whatever the test temperature be. After estimating T_0 and fitting the scatter in the transition range by Weibull distribution, it is possible to estimate the whole transition region curve by means of the master curve and tolerance bounds. The upper bound (95%) and lower bound (5%) curves are expressed using the following equation,

$$K_{JC(0.xx)} = 20 + \left[\ln\left(\frac{1}{1-0.xx}\right)\right]^{1/4}\{11 + 77\exp[0.019(T - T_0)]\} \quad ,$$

where, 0.xx is the cumulative probability level.

Besides, from the similar results of other ferritic steels it also observed that, the shape of the curve remain unaltered for any ferritic steel and only the value of T_0 varies for different material. Thus the curve represented by the above eqn. is valid for any ferritic steel by appropriately positioning in the temperature axis by the corresponding T_0. Therefore this curve is the Master curve for fracture toughness of Ferritic Steels in ductile to brittle transition temperature (DBTT) range. Hence T_0 is the single parameter which along with the Master curve can describe the scatter and temperature dependence of fracture toughness in DBTT range for any ferritic steel. Thus T_0 is the measure of ductility or brittleness of a material in the transition range in Master curve methodology which can be measured by determining fracture toughness K_{JC} of at least six specimens at a single or multiple temperature(s). Here remains the significance of Master Curve and reference temperature T_0 in advanced structural integrity. The embrittlement (loss of ductility or reduction of fracture toughness) of a material due to induced radiation or temperature can be assessed by measuring T_0 of the material at that status. The ease of the method and requirement of small number of experiments establish the usefulness of this Master Curve approach for surveillance program. The different observations and recommendations regarding Master curve of fracture toughness in DBTT range have been explored in last two decades through organized experimental and theoretical research activities under the guidance of IAEA [7]. The test methodology, specimen standard, guidelines for censoring and size limit, computation of K_{JC}, test environment have been described in ASTM E-1921.

Experimental Work

As a part of research investigations on Master Curve, large number of experiments has been carried out on 1T & ½ T CT specimens at temperature range of RT to -140°C in collaborations with Jadavpur University (Kolkata). The important observations related to Master curve have been explored for the RPV material 20MnMoNi55 and results are discussed below. The test results and observations can be significant for the structural integrity analysis. The major objectives of the projects were to:

(i) Determine the fracture toughness K_{JC} of the material from 20°C to -140°C from J-R test results of 1T and ½ CT specimens, (ii) Determine K_{JC} vs. temperature distribution, (iii) Evaluate T_0 using multi temperature and single temperature methods for varied thickness, test temperature and a/w ratio, (iv) Study the effect of computation method, test temperature, test temperature range, specimen thickness, a/w ratio on T_0 and Master curve in the transition range.

The matrix of the various samples from which Master Curve and T_0 have been evaluated is as shown in Table 1. Fig.3 shows the photograph of test set up. Figs. 4-17 show the Master Curve and T_0 for various test parameters.

Table 1: Test matrix, sample details, test temperature and T_0 values

Sample no	Sample size (N)	Specimen	Thickness, mm	a/W ratio Temp. (°C)	Test	T_0 (°C)	Remarks
1	06	1T CT	25	0.45–0.50	–80 °C	–132	Invalid
2	06	½ T CT	12.5	0.50–0.54		–127	Fig. 4
3	12	1T & ½ T CT	25, 12.5	0.45–0.54		–130	Fig. 5
4	06	½ T CT	12.5	0.50–0.54	–100 °C	–125	Fig. 6
5	09	1T & ½ T CT	25, 12.5	0.45–0.54		–123	Fig. 7
6	09	1T–CT	25	0.45–0.50	–110 °C	–130	Fig. 8
7	06	½ T CT	12.5	0.50–0.54		–130	Fig. 9
8	15	1T & ½ T CT	25, 12.5	0.45–0.54		–130	Fig. 10
9	24	1T–CT	25	0.45–0.54	–80, –100, –110, –120, –130 & –140°C	–129	Fig. 11
10	21	½ T CT	12.5	0.45–0.54		–126	Fig. 12
11	45	1T & ½ T CT	25, 12.5	0.45–0.54		–129	Fig. 13

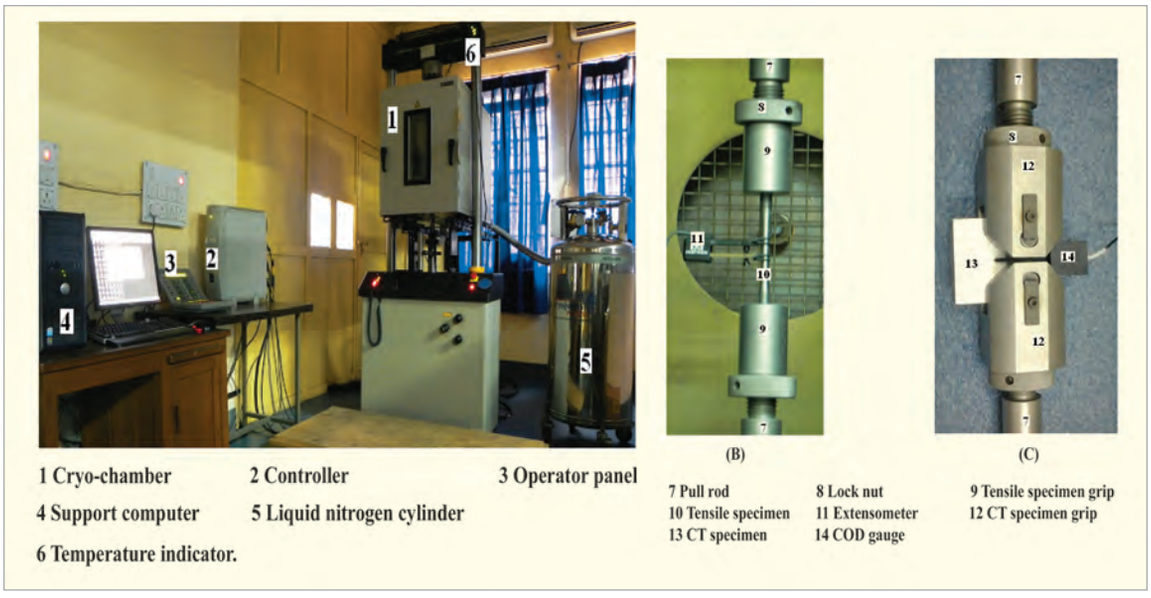

Fig.3: Photograph of 100 kN grip capacity Universal testing machine with low temperature test set up

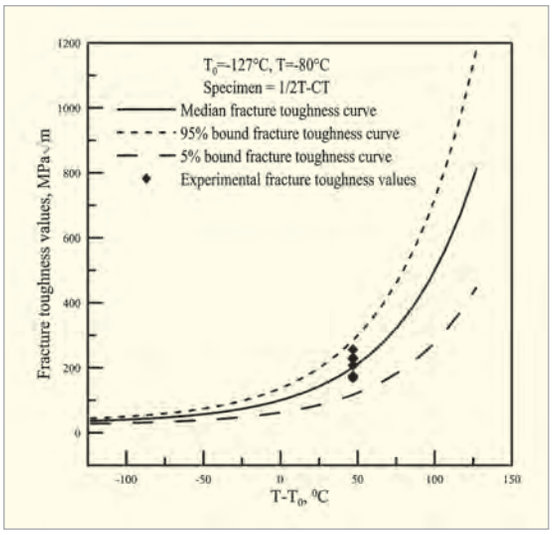

Fig. 4

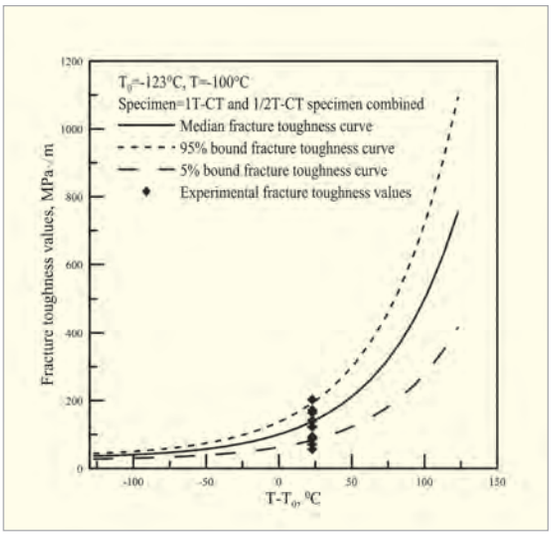

Fig. 7

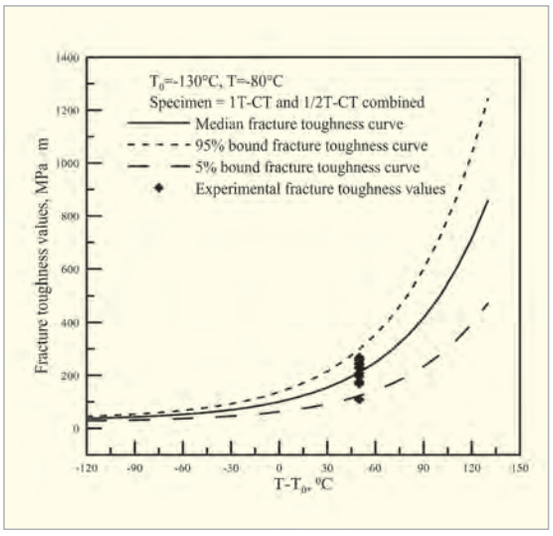

Fig. 5

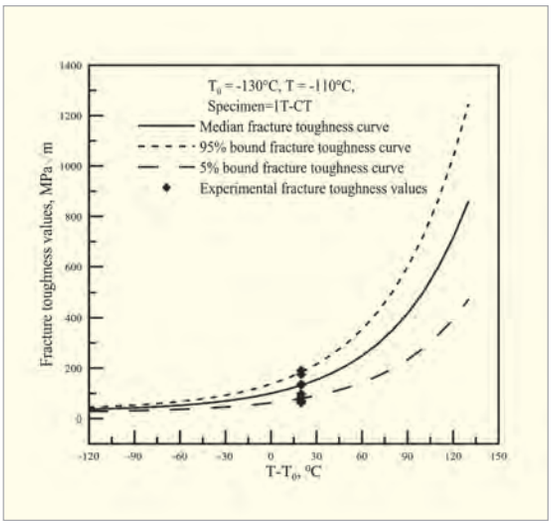

Fig. 8

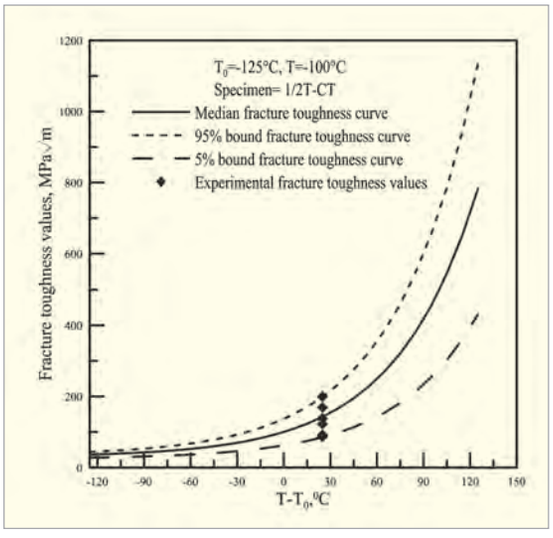

Fig. 6

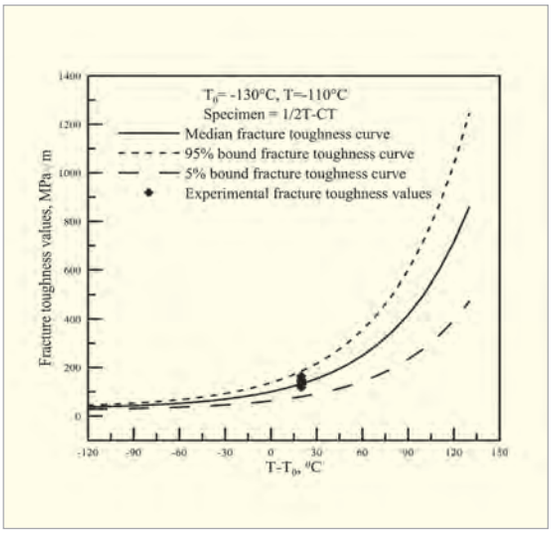

Fig. 9

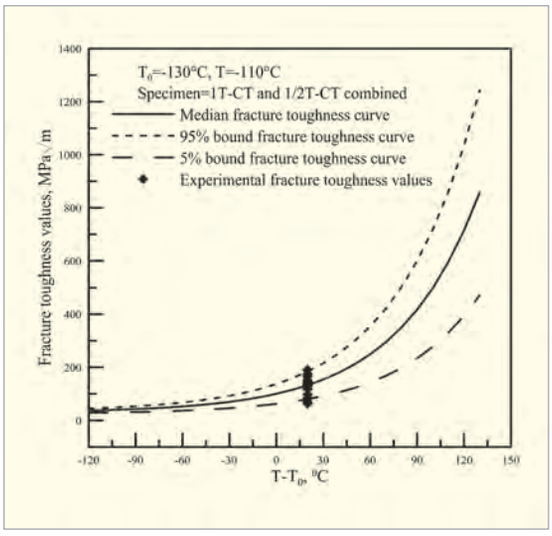

Fig. 10

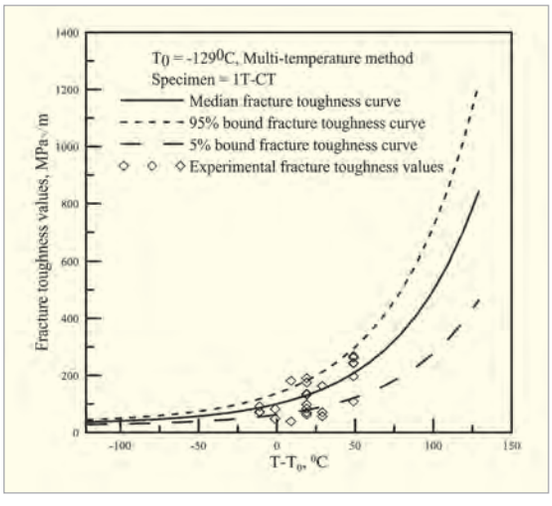

Fig. 11

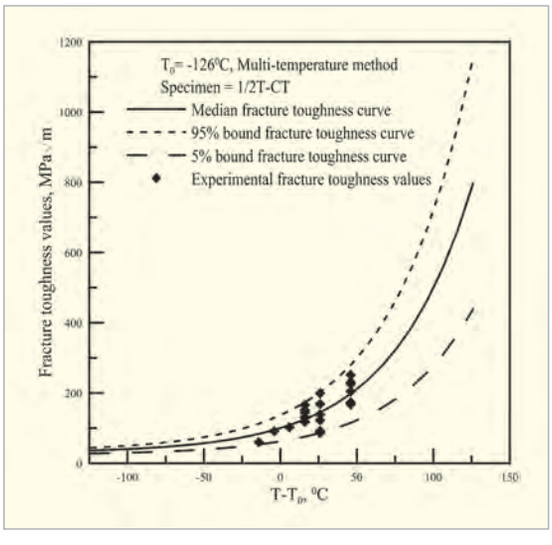

Fig. 12

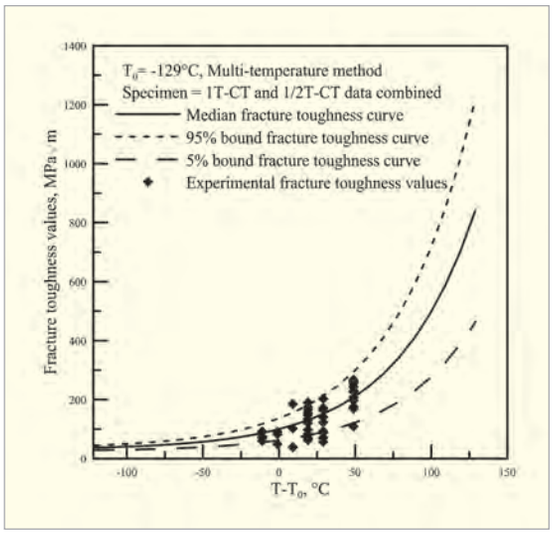

Fig. 13

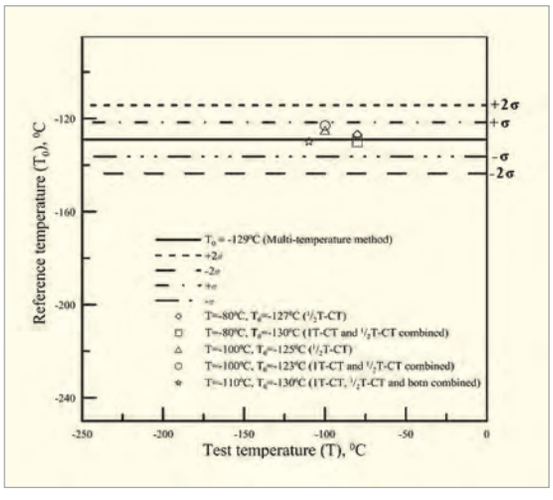

Fig. 14

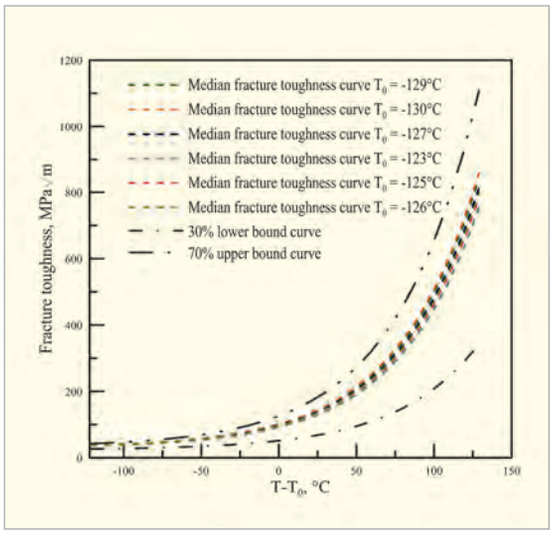

Fig. 15

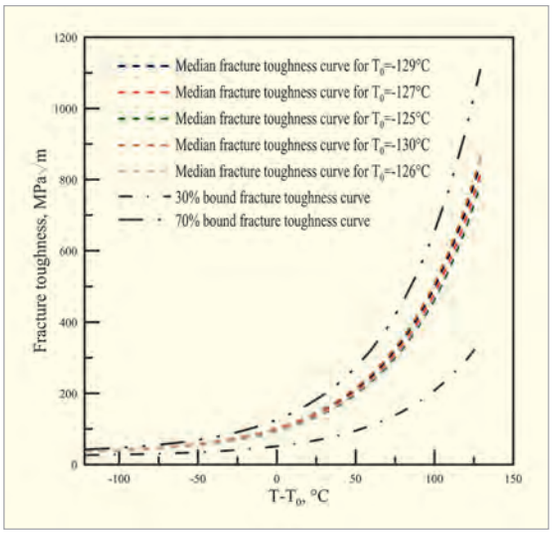

Fig. 16

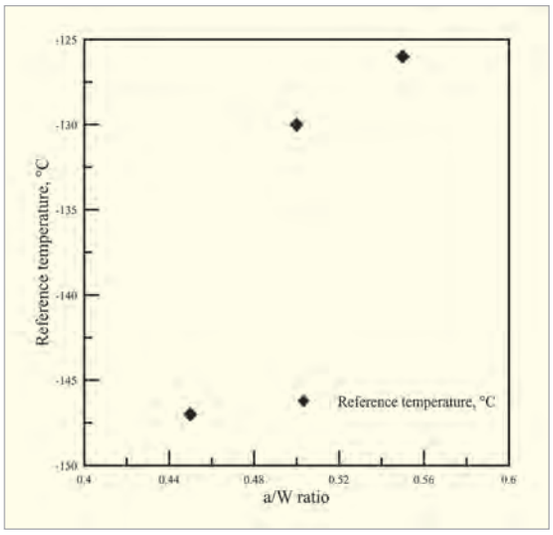

Fig. 17

Analysis of Test Results and Observations

From the test results, following observations are made [8-9]:

1. The fracture toughness values are very scattered at any temperature in DBT regime and brittle fracture is observed beyond and from –80°C for both 1T–CT and ½T–CT specimens.
2. Master curve reference temperature T_0 obtained by combining all the 1T-CT and ½T–CT fracture toughness values and using multi-temperature method are considered as best characterizing curve for this material. All the master curves and reference temperature values obtained by different methods, specimen size and a/W ratios are compared with this curve. It is observed that all the curves falls within the 70% and 30% bound of the best characterizing curve. The observations are similar as mentioned in coordinated research programme by IAEA [10].
3. The variation in reference temperature for 1T–CT and ½T–CT specimens for different methods is within ±5°C. Also the T_0 are evaluated using multi-temperature evaluation method for 1T–CT and ½T–CT specimens separately, it is observed that reference temperature variation is within ±3°C. Hence the correction suggested for thickness adjustment is found to effective for this material [11].
4. When the different combinations of test temperatures are used to evaluate T_0, it is observed that the value of reference temperature is more consistent as the number of test temperature considered increases. The correlation coefficient of T_0 with temperature range is measured using Pearson's product-moment correlation coefficient and it shows that T_0 is linearly dependent on range of test temperature. Also the effect of *a/W* variation on the reference temperature is noticeable. More experiment is required to study the effect of *a/W* on reference temperature in details.
5. The reference temperature is independent of specimen size and test temperature for this material.
6. The multi-temperature method for evaluating the T_0 is the most effective way to capture the scatter and temperature dependent of fracture toughness. But for convenience, single temperature evaluation method also is proposed in master curve methodology and found to be effective. For negligible variation in reference temperature derived from different methods and differently sized specimen one can derive the reference temperature by single temperature

evaluation method and $^1/_2$T-CT specimens to reduce time, material utilization and cost also.

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Design, Development and Deployment of Special Sealing Plug for 540 MWe PHWRs

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Abstract

The coolant channel in Pressurized Heavy Water Reactors is a pressure boundary component and is very important for reactor performance and reactor safety. Monitoring the condition of the pressure tube of each coolant channel on a periodic basis is very important. In-Service Inspection (ISI) of the coolant channels in water filled condition is done regularly for 220 MWe PHWR. For the same purpose BARC Channel Inspection System is developed for 540 MWe PHWR also. Special Sealing Plug has been developed to facilitate the channel inspection (in water filled condition) with all necessary safety features at par with normal sealing plug. Special Sealing Plug provides a 50 mm through hole for passage of drive tube of Inspection Head maintaining integrity of PHT. Lot of challenges were faced for developing the Special Sealing Plug and its associated tools. It was a first of its kind design. First ISI of TAPS-4 was conducted successfully using this plug along with associated tools in November 2011. This development has provided immense help to NPCIL in life management of 540 MWe PHWR coolant channels.

Introduction

The coolant channel in Pressurized Heavy Water Reactor (PHWR) is a very important component both from the point of view of reactor performance and reactor safety. The coolant channel basically comprises of pressure tube with an end-fitting on either side. Each end fitting houses sealing plug, shield plug and fuel locator. Pressure tube houses 13 number of fuel bundles. The coolant, heavy water, flows through these fuel bundles at high pressure & temperature conditions. A concentric calandria tube envelops the pressure tube. Calandria tube is surrounded by moderator i.e. heavy water. The annular gap between the pressure tube and the calandria tube is filled with CO_2 gas essentially meant to thermally insulate the high temperature pressure tube from the relatively low temperature moderator. A 540 MWe PHWR unit has 392 coolant channels. Any type of damage in pressure tube may lead to crack or complete breakage of pressure tube affecting the integrity of the coolant channel that is of critical importance to reactor performance and reactor safety. Because of these reasons, periodic monitoring of the condition of the pressure tube is very important.

In-Service Inspection (ISI) of the coolant channel is carried out in water filled condition. For this purpose BARC Channel Inspection System (BARCIS) is developed for 540 MWe PHWRs (Fig. 1). This system is a scaled-up version of BARCIS for 220

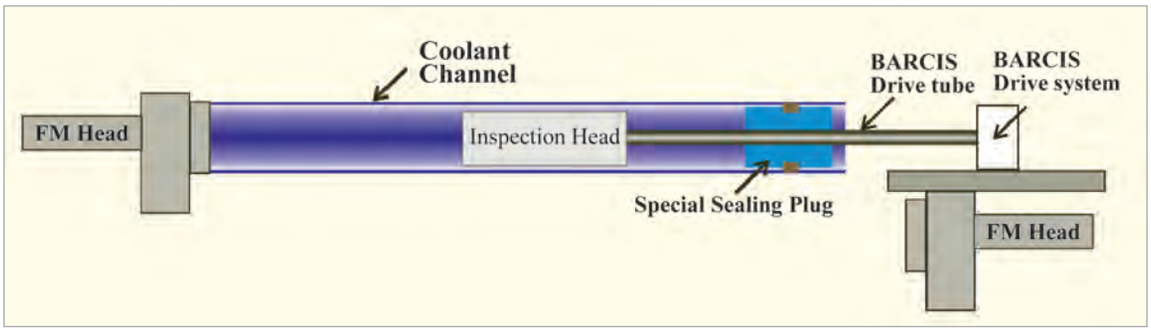

Fig. 1: BARCIS schematic during operation

MWe PHWRs. BARCIS consists of an Inspection Head, a Special Sealing Plug (SSP), a drive system to give axial and rotary motion to the inspection head and a control system for drive. Inspection Head of BARCIS consists of various sensors for monitoring health of the channel. Special Sealing Plug (Fig. 2) is required to maintain water leak tight path for Drive Tube insertion, its rotary and axial movements. An Adaptor (named as SSP Adaptor) is used to locate SSP in magazine of Fuelling Machine with jaws of SSP in collapsed condition and also for installation of SSP in the end fitting. SSP Adaptor remains in Fuelling Machine magazine during ISI.

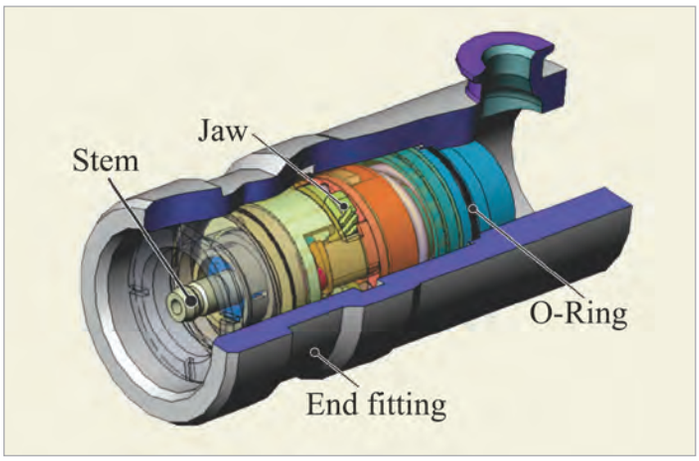

Fig. 2: 3D visualization of Special Sealing Plug installed in End fitting

Design manual was prepared, and safety clearance was obtained for using BARCIS in reactor. Integrated testing was carried out successfully in Calibration and Maintenance Facility. Training was given to the Fuel Handling Crew at TAPS-3&4. The system was deployed in TAPS-4and ISI of 16 numbers of channels was carried out in November 2011. The performance was found to be satisfactory despite being first of its kind design.

The Scheme

The inspection head which does the function of inspection of coolant channel is held in position by special sealing plug with the help of stem and locknut. During ISI the Special Sealing Plug and inspection head form an assembly this assembly is installed in the end fitting by the fuelling machine rams using SSP Adaptor. In Fuelling Machine, SSP Adaptor, SSP and Inspection Head assembly are housed in magazine in floating condition. Fuelling Machine is clamped to the channel due for ISI and replaces the normal sealing plug with the special sealing plug & inspection head assembly after defueling the channel. Inspection head travels till the other end of the channel by using the extensions through the Special Sealing Plug by using BARCIS drive system. After completion of the inspection job the extensions are retrieved and special sealing plug's stem and lock nut are reinstalled. The Special Sealing Plug is replaced by the normal sealing plug by the fuelling machine after normalising the channel.

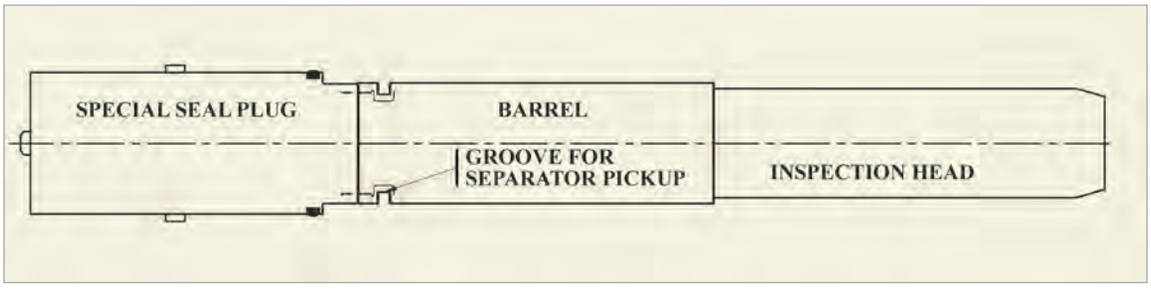

Fig. 3: Special Sealing Plug and Inspection Head assembly

Safety Features of SSP

The SSP is compatible with BARCIS-540 and Fuelling Machine. In 220 MWe PHWR SSP, the plug is held in the channel using balls and the safety latch action is achieved by Ram-B action. In the SSP of 540 MWe PHWR jaws have been provided and safety latch is fully functional. This modification avoids overhauling requirement and enhances ejection resistance for the plug.

The plug is as safe as the normal sealing plug. The latch acts as in normal sealing plug and provides a solid mechanical stop to the jaws directly. After removal of the stem and latch sleeve by opening the locknut it is not possible to transfer force by drive tubes since the plug is housed with a stationary sleeve outside the drive tube. The latch is disengaged by only latch ram movement without moving the stem.

Other Major Assemblies

The SSP requires some associated assemblies during ISI and installation using Fuelling Machine. The Fuelling Machine requires SSP Adaptor to install SSP in the end fitting. The other tools are, Stem Lock Safety Latch Gauge, Stem Pusher, Pneumatic Pusher used at the time of ISI.

SSP Adaptor

The SSP with Inspection Head (IH) needs to be located in the magazine of Fuelling Machine. Jaw grooves in the tubes of the FM magazine are situated towards snout side and the SSP and IH assembly cannot be housed in the magazine tube with jaws of SSP in jaw grooves due to longer length of assembly.

A new device was conceptualised to locate SSP and IH assembly in the magazine with jaws of SSP in collapsed condition. It was a challenge to conceptualise the SSP Adaptor (Fig. 4) due to its contradictory requirement of collapsing jaws and also expanding jaws in end fitting, with all feedbacks. Axial space available to accommodate SSP Adaptor is limited. The SSP Adaptor acts as a ram extension when SSP is installed in end fitting, and locks jaws in collapsed condition when installed in magazine.

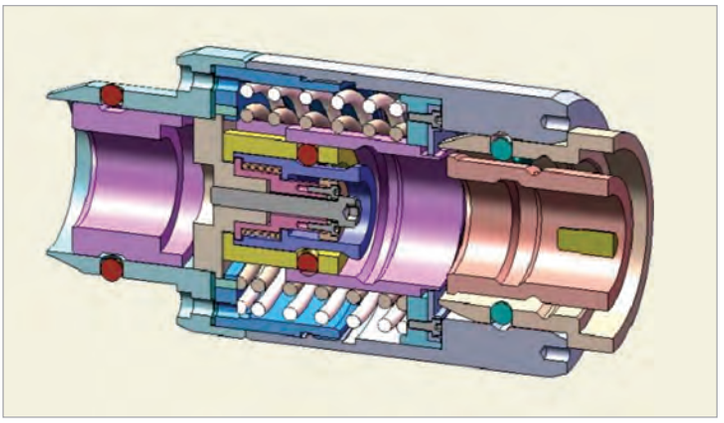

Fig. 4: SSP adaptor, 3D visualization of cross-section

Stem Lock & Safety Latch Gauge

The Stem Lock & Safety Latch (SLSL) Gauge is also called SLSL Gauge (Fig. 5). When the SSP is installed properly in the end fitting (jaws fully out) the stem to SSP body front dimension is within 4 to5 mm and latch is engaged i.e. out by 10 mm. The SLSL Gauge is a simple electronic device which provides audio visual feedback of this dimension with failsafe design philosophy.

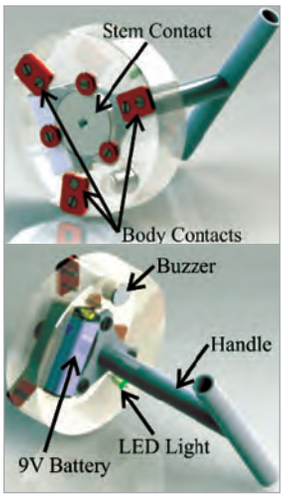

Fig. 5: SLSL gauge

Qualification of Special Sealing Plug and Associated Tools

As SSP is a part of PHT boundary, any failure will result in loss of coolant / heavy water and consequent man-rem consumption. The SSP and tools were conceptualised to make these assemblies error proof, however to reduce manual errors check lists have been prepared and training was given to operating personnel.

The SSP and tools were subjected to stringent QA. The SSP and tool were thoroughly tested for qualifying the design. The design was reviewed by various departmental safety committees. Functional testing was carried out successfully at site in reactor simulated conditions.

Challenges Faced during Development

a) The SSP for 540 MWe was designed with 50 mm centre bore for drive tube insertion and fully functional jaws and latch. There is limited space available to accommodate all these features. It was a challenge to implement the features in this limited space with good reliability and strong components.

b) The SSP with Inspection Head needs to be located in the magazine of FM. The FM Magazine jaw grooves are in front side of FM; the SSP and IH assembly cannot be housed in the Magazine with jaws of SSP in jaw grooves due to longer length of assembly. This was realised at the end of development stage; thus giving a major setback to the BARCIS program. A new device (SSP Adaptor) was conceptualised to deposit SSP and IH assembly in the magazine with jaws of SSP in collapsed condition. It was a challenge to conceptualise the SSP Adaptor due to its contradictory requirement of collapsing jaws in the magazine tube and also expanding jaws in the end fitting, with all feedbacks. Axial space available to accommodate SSP Adaptor was also limited.

c) Nuclear Power Corporation India Limited decided to use improved version of Ram Manipulator (named as Ram Manipulator MK-

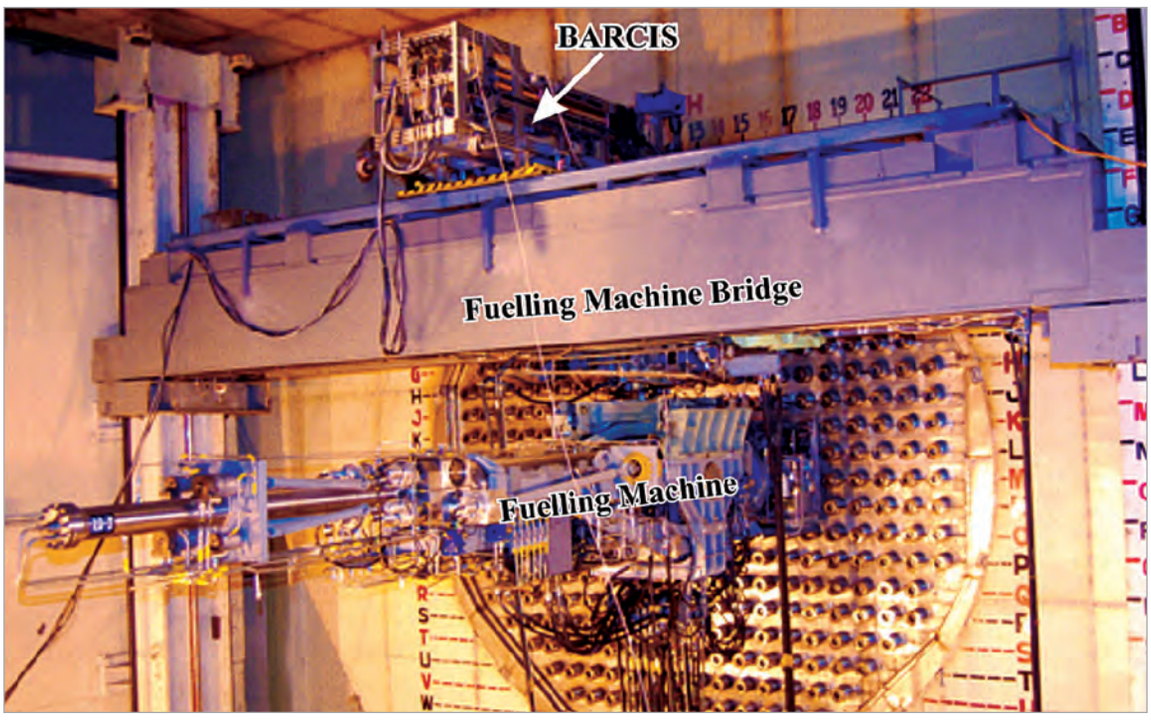

Fig. 6: BARCIS in action in TAPS-4

II). The MK-II manipulator is having latch interlocking balls and hence independent C-Ram and Latch movement is not possible for all ranges of motion. The SSP Adaptor utilises independent Latch and C-Ram movement to operate and hence design / procedure in the adaptor was modified.

ISI in TAPS-4

Design and operating manuals were prepared for training of the personnel at TAPS. FH crews were qualified based on written test and mock-up trials.

After successful demonstration and qualification, ISI of TAPS-4 was commenced on 23 November 2011. The first channel took about 22 hours to complete. This abnormally higher time was attributed to full volumetric scanning of the channel and garter spring detection problems. After second channel the garter spring location problem was sorted out.

Volumetric scanning (axial and circumferential) resulted in high stress on the ID of O-rings of the SSP which was not considered during entire design phase of the SSP. The total rubbing travel in a channel was estimated to be 550 metre, which is high for dynamic O-rings of this nature. The SSP performed satisfactorily for ISI of all the 16 channels.

Conclusion

BARC Coolant Channel Inspection System (BARCIS) was required to be developed on priority to facilitate ISI of coolant channels in TAPS-4, a lead reactor of 540 MWe PHWRs. Design evolution of SSP and SSP Adaptor was a challenge in case of 540 MWe BARCIS. New design features were incorporated to take care of safety and maintenance issues, viz. increased load bearing capacity equivalent to normal sealing plug, fully functional safety latch, bigger drive tube hole and no time based overhauling / maintenance requirement.

Design was improved by iterations on prototype plug and final design was qualified. Integrated testing with BARCIS was carried out. Training and qualification programme was conducted for site operators.

ISI of 16 channels was carried out in November 2011. Performance of the plug and the associated tools was found satisfactory. Thus development of Special Sealing Plug is a remarkable step towards developing inspection technology for bigger size PHWRs.

Decontamination of Alpha Contaminated Metallic Waste by Cerium IV Redox Process

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Abstract

Decontamination of alpha contaminated metallic waste is an important aspect in the management of waste generated during dismantling and decommissioning of nuclear facilities. Present work on cerium redox process targets decontamination of alpha contaminated metallic waste till it qualifies for the non alpha waste category for disposal in near surface disposal facility. Recovery of the alpha radio nuclides and cerium from aqueous secondary waste streams was also studied deploying solvent extraction process and established. The alpha-lean secondary waste stream has been immobilised in cement based matrix for final disposal.

Key words: Decontamination, Redox process, Cerium, Waste, Extraction

Introduction

Alpha contaminated metallic wastes generated from reprocessing and radio metallurgical operations need to be decontaminated prior to their disposal. The adherence of alpha contaminants on metallic objects could be either by physical or chemical bonding to the substrate. Over a period of time this contamination migrates in to pores and microscopic voids of a material surface and gets fixed and is difficult to remove by any physical decontamination processes. To address decontamination of those materials with fixed contamination, hard chemical decontamination processes are required. Among various processes, the cerium redox process appears to be more promising. In this process metallic surface congruently dissolves in cerium (IV)-bearing nitric acid medium resulting in decontamination. The present study was undertaken to evaluate cerium redox process for decontamination of alpha contaminated metallic waste with an attempt to qualify them as non alpha waste category. Besides, a process based on solvent extraction was established to recover the alpha radio nuclides (Pu, Am) and also inactive Ce ions from the spent nitric acid for recycling.

Chemistry of redox decontamination process

The alpha contaminated metallic waste is mainly SS 304L. Ce^{4+} is a strong oxidising agent (E_0 = 1.60 volts in 4 M HNO_3) and can efficiently oxidise the constituents of SS as well as Pu^{4+} to Pu^{6+} as per following redox chemical reactions:

- $3Ce^{4+} + Fe = Fe^{3+} + 3Ce^{3+}$ E_0 Fe/Fe^{2+} = 0.04 V
- $2Ce^{4+} + Ni = Ni^{2+} + 2\,Ce^{3+}$ E_0 Ni/Ni^{2+} = 0.25 V
- $6Ce^{4+} + Cr = Cr^{6+} + 6\,Ce^{3+}$ E_0 Cr/Cr^{6+} = 0.41 V
- $Pu^{4+} + 2Ce^{4+} = Pu^{6+} + 2Ce^{3+}$ $^{+}E_0$ Pu^{4+}/Pu^{6+} = 1.03 V

In general contamination gets extended up to depth of 10 to 12 micron from surface. Removal of this thickness of layer can result in overall effective decontamination. The rate of metallic corrosion depends on the concentration of ceric ion, nitric acid as well as temperature. To maintain a uniform corrosion rate, it is required to regenerate the reduced Ce^{3+} into the Ce^{4+} state during the decontamination. Ce^{4+} can be easily regenerated either by electro oxidation or by chemical oxidation employing ozone. The process of oxidation by ozone gas is relatively simpler and amenable to online conversion.

Results and Discussion

Study of Ce^{3+} to Ce^{4+} conversions in experimental loop.

A glass bubble reactor of one litre capacity for online conversion of Ce^{3+} to Ce^{4+} by ozone was designed and fabricated in-house. The decontamination solution was continuously circulated in reactor from decontaminating chamber and ozone gas was continuously passed through the reactor (Fig. 1). The un-reacted ozone was passed through two scrubbers in series containing H_2O_2 and KI and then through furnace at 600°C to ensure complete destruction of ozone.

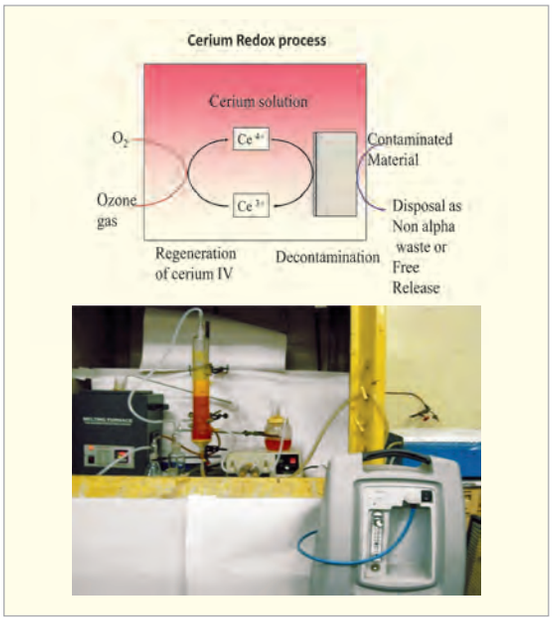


Fig. 1: Schematic of Cerium redox process and experimental setup

Initially, experiments were conducted at varying acidity and temperature at about 5 g/h output of ozone for study of Ce^{3+} to Ce^{4+} conversion rate without the work piece. It was observed that 0.4 M concentration of Ce^{3+} in 4 M HNO_3 at room temperature could be quantitatively oxidised to Ce^{4+} in about four hours. At 60°C this time of conversion reduced to half (Fig. 2). Based on these studies decontamination experiments were conducted in batch mode with inactive and alpha contaminated samples.

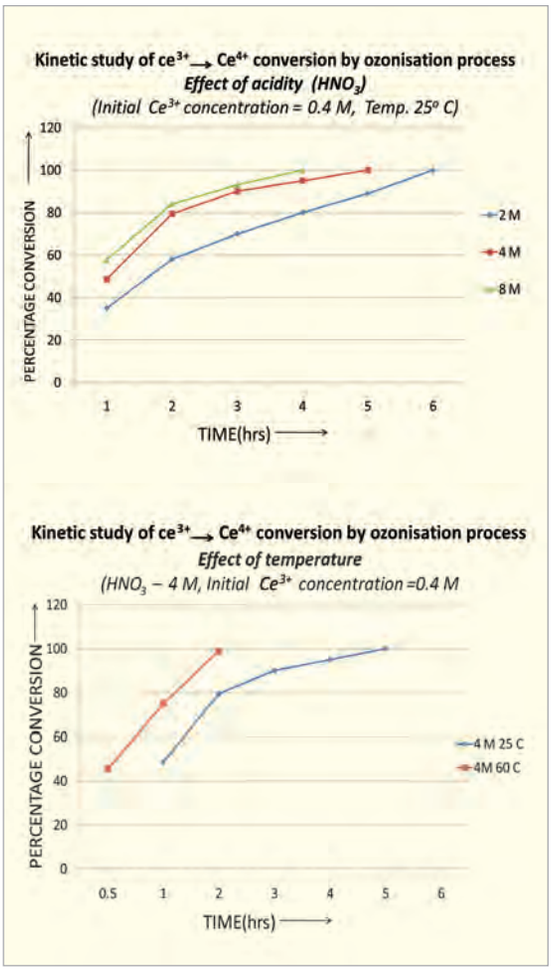


Fig. 2: Effect of acidity and temperature on Ce^{3+} to Ce^{4+} conversion by ozone

Decontamination study on inactive coupons

Corrosion of inactive SS planchets were carried in solutions with varying concentration of Ce^{4+}/Ce^{3+} in 4 M HNO_3 at different temperatures to determine optimum conditions for efficient corrosion kinetics. The ratio of surface area of coupon to volume of decontaminant solution was maintained at 1:10. In none of the following experiments, ozone gas was not employed for regeneration of Ce^{4+}. The surface roughness and weight loss results are shown in Table 1. Micro structural examination of the experimental coupons was also done deploying Scanning Electron Microscope. The results indicate that the overall corrosion was practically uniform (Fig. 3).

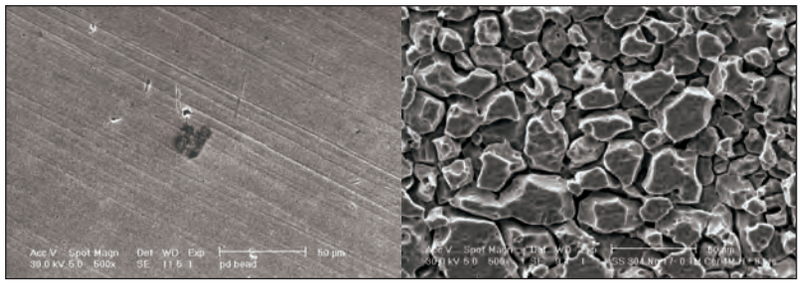


Fig. 3: Surface morphology of virgin and corroded SS planchet

Table 1: Corrosion and Decontamination of SS coupons with Ce^{4+} solutions

Corrosion of inactive SS coupons						
Initial Ce^{4+}/Ce^{3+} (mole ratio) in 4 M HNO_3	Init wt. (g)	Wt. Loss(g)		Corrosion rate		Roughness Index (μ)
		2 hrs	8 hrs	Mpy.	μ/hr	
Nil	1.199	0	0	0	0	0.055
0.4/0.0	1.172	0.021	0.151	837	2.44	2.405
0.3/0.1	1.156	0.015	0.115	636	1.84	1.98
0.2/0.2	1.181	0.011	0.098	555	1.61	1.73
0.1/0.3	1.180	0.012	0.062	345	1.0	0.593

Table 2: Decontamination of SS coupons with Ce^{4+} solutions

Decontamination of active SS coupons at room temperature (25°C)			
Initial Ce^{4+}/Ce^{3+} (mole ratio) in 4 M HNO_3	Initial Counts (CPM)	Final Counts (CPM)	DF
0.2/0.2	6,281	8.5	738
	62,161	6.5	9,563
0.4/0.0	10,060	1.0	10,060
	43,562	1.5	29,041
Decontamination of active SS coupons at elevated temperature (60°C)			
0.2/0.2	8,400	3.3	2,545
	43,070	1.0	43,070
0.4/0.0	16,090	1.0	16,090
	27,545	1.0	27,545

Decontamination study on active coupons

Similar experiments were, subsequently, conducted with Pu contaminated SS planchets with fixed contamination. The samples were dipped in decontaminating solution with varying initial Ce^{4+}/Ce^{3+} ratio in 4 M HNO_3. The solution was stirred intermittently during the experiment in all the cases lasting for two hours. It was observed that planchets could be decontaminated more efficiently with higher initial concentration of Ce^{4+} solution and at higher temperature (Table 2).

Decontamination study on actual alpha contaminated metallic samples

Actual radioactive contaminated samples collected from RMD, BARC of various shapes, and from different origin with varying level of Pu contamination were successfully decontaminated to non alpha category with 0.4M Ce^{4+} solution in 4 M HMO_3 in batch mode (Fig. 4). Decontamination experiment of SS spatula used for PuO_2 powder handling in glove box was carried out in multiple steps. Initially, the spatula was immersed in 100 ml of 4M nitric acid for two hours with occasional mixing. Analysis of the solution showed about 25% decontamination in two hours. In the next step, the spatula was immersed in a fresh lot of 100 ml 4M nitric acid for four more hours in a similar way. This resulted in further ~25% decontamination. Further decontamination was not observed with nitric acid. The spatula was, subsequently, subjected to decontamination using 0.4M ceric nitrate in 4M nitric acid solution at room temperature. Fig. 5 shows Pu concentration with time in the decontamination solution. The results show that the progress of decontamination reaction was steady till eight hours (~98%) and thereafter it was monotonous. The percentage decontamination after twelve hours was 99.2. The spatula was later immersed in fresh ceric nitrate solution for another two hours. This resulted in near total decontamination of the spatula qualifying it as non-alpha waste. These results showed that Ce (IV) based redox process is effective for decontamination of alpha contaminated SS surfaces. The time of decontamination can be reduced by online regeneration of Ce (IV) using Ozone.

SS Spatula **SS ring**

Fig. 4: Alpha contaminated SS samples

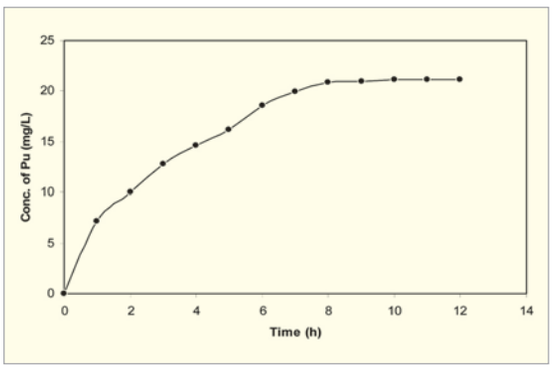


Fig. 5: Decontamination behaviour of alpha contaminated SS spatula

Management of spent decontamination solution

The resultant decontamination solution after few cycles will contain substantial amount of alpha activity (mainly due to Pu and trace activity due to ^{241}Am) in addition to inactive constituents like Fe, Ni, Cr and Ce. Recovery of α activity and inactive Ce from such solution is very important from waste management considerations. The majority of cerium is expected to be present in ceric state whereas Pu and Am will be present in hexavalent and trivalent states respectively. Among the various methods, solvent extraction was preferred because of high separation factors.

Recovery of Pu from spent decontamination solution

Conventional PUREX solvent was employed for the recovery of Pu from such medium after reducing ceric to its non-extractable trivalent state using $NaNO_2$ or H_2O_2 as reducing agent. Under these conditions, Pu is converted to more extractable tetravalent state in TBP phase compared to its hexavalent state. To optimize the process parameters, preliminary experiments were carried out in batch mode under different experimental conditions. The experimental results indicate that both H_2O_2 and $NaNO_2$ can be used for conditioning ceric to cerous and PuO_2^{2+} to its tetravalent state during extraction. Organic to aqueous (O:A) phase ratio of 1:3 was

found optimum to have greater than 70% extraction in a single contact. In five multiple contacts, quantitative extraction of Pu was achieved. Loaded organic was stripped using mixture of Hydroxylamine Nitrate (HAN) and nitric acid. Optimized concentration of indigenously synthesized HAN (0.3M) and HNO_3 (0.6M) mixture was used for Pu stripping. Quantitative stripping of Pu in three contacts at 3:1(O:A) phase ratio was observed. These studies clearly show that TBP can be employed for the extraction of Pu^{4+} from secondary aqueous waste containing decontaminating reagent. Plutonium product solution can be concentrated using conventional techniques and recycled. Further extraction and stripping experiments were carried out using a real waste generated from decontamination of contaminated metallic waste. Pu concentration of the composite waste was ~20 mg/L. Results from extraction and stripping are given in Tables 3 and 4 respectively.

Counter-current Studies

After solvent extraction studies in batch mode, extraction and stripping experiments were extended to counter-current mode using laboratory scale mixer-settlers. Simulated feed solutions were prepared by mixing solutions from various stages of decontamination studies. The concentration of Pu

Table 3: Batch extraction of Pu^{4+} from aqueous phase containing waste

Experimental Conditions
Conc. of Pu in waste solution: 21.59 mg/L,
Reductant : 0.10M $NaNO_2$,
Phase Ratio (O/A): 1:3 (5 ml :15 mL),
Contact Time : 15 min.

Contacts No	[Pu] in Feed (mg/L)	Plutonium Extraction	
		Raff. (mg/L)	Extn. (%)
I	21.59	7.09	67.17
II		2.75	87.26
III		1.60	92.77
IV		0.73	96.62
V		ND	~100

Table 4: Stripping of Pu from Pu loaded TBP phase using HAN+HNO_3

Experimental Conditions
Conc. of Pu in Org. phase: 15.40 mg/L,
Strippant: 0.30M HAN+0.6M HNO_3
Phase Ratio (O/A): 3:1 (15 mL : 5 mL) ,
Contact Time: 15 min. for each.

Contacts	[Pu] in Feed (mg/L)	Plutonium Stripping	
		Conc. in stripped aqueous phase (mg/L)	Cumulative Stripping (%)
I	15.40	22.86	49.48
II		15.90	83.90
III		6.85	98.72

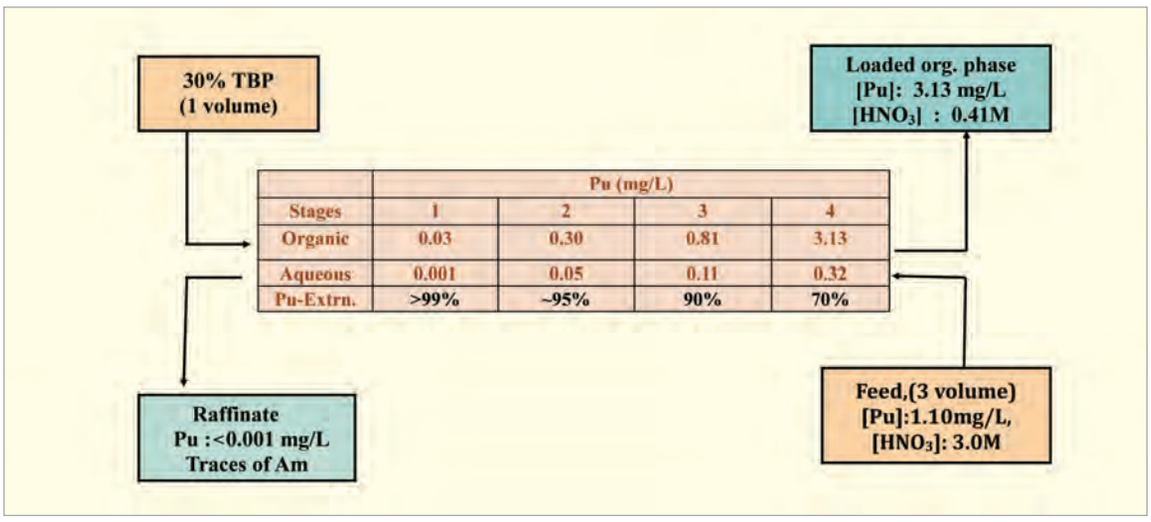
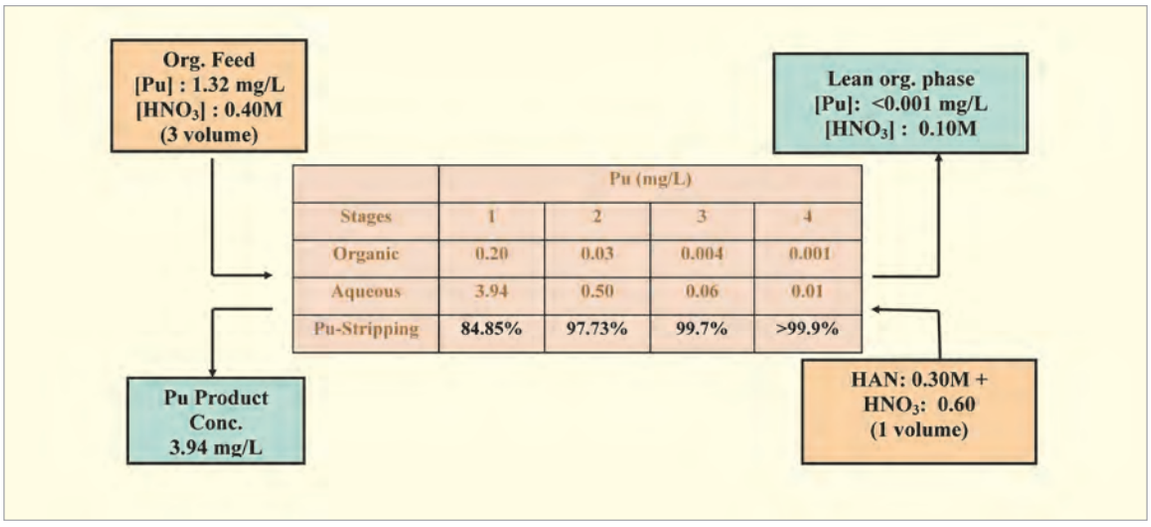


Fig. 6: The results from counter-current extraction run



	Pu (mg/L)			
Stages	1	2	3	4
Organic	0.20	0.03	0.004	0.001
Aqueous	3.94	0.50	0.06	0.01
Pu-Stripping	84.85%	97.73%	99.7%	>99.9%

Fig. 7: Results from counter-current stripping run

in the feed was 1.1 mg/L and that of Ce^{4+} was ~0.40M at acidity of ~3.0M HNO_3. The organic to aqueous phase ratio of 1:3 using 30% TBP in n-dodecane as extractant was maintained during the experiment. The exit samples were taken periodically to check the steady state conditions. About 3L loaded organic phase was generated from extraction run and used for stripping experiment at an O/A ratio of 3:1 using 0.30M HAN+0.6M HNO_3 as strippant. Stage samples were taken at the end of each run (Fig. 6). The experimental results indicate that quantitative extraction of Pu in four stages is achieved. Pu lean raffinate showed traces of ^{241}Am with entire Ce along with SS corrosion products. The results from counter current stripping run using HAN+HNO_3 are given in Fig. 7. Organic phase after stripping showed Pu concentration below 0.001mg/L indicating stripping efficiency greater that 99.9%.

Recovery of Ce and ^{241}Am from raffinate

The Ce and Am in raffinate are present in trivalent state along with SS corrosion products. Ce^{3+} to Ce^{4+} oxidation was selectively effected by ozone and quantitatively recovered in 30% TBP in n-dodecane. It was observed that Am^{3+} does not get extracted under these conditions and remains in aqueous phase. Ce^{4+} in organic phase was reduced to Ce^{3+} by $NaNO_2$ as reductant and stripped with HNO_3 to avoid Ce hydrolysis. Am was finally extracted from the raffinate by employing 0.2M THEDGA as extractant in 30% isodecyl alcohol in n-dodecane. The organic phase was stripped with 0.01M HNO_3 to recover Am in aqueous phase and concentrated for further use. The Ce recovered can be recycled back for decontamination processes.

Management of aqueous raffinate

The raffinate after recovery of Pu, Am and Ce is only potentially alpha active with major concentration of SS corrosion products in acidic medium and can be managed as non alpha category waste. The raffinate was neutralised with sodium hydroxide and the sludge formed was fixed in cement matrix. The product formed with water to cement ratio of 0.5 and with 20 wt% of waste loading was found to have desired product characteristics and qualify for near surface disposal.

Conclusion

The process of decontamination of α-contaminated metallic waste to non α-category by cerium redox process has been optimized. The process was demonstrated at laboratory scale using actual alpha contaminated metallic samples received from RMD, BARC. The study has also demonstrated the recovery of alpha radionuclides and management of secondary waste generated from decontamination.

Non-Invasive Blood Pressure Monitor: Beat to Beat

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Abstract

Non-Invasive Blood Pressure Monitor has been developed at Electronics Division, BARC. It comprises of an Oscillometric, Impedance Plethysmographic (IPG), Photo Plethysmographic (PPG) and Electrocardiographic (ECG) modules. Oscillometric module facilitates spot or periodic measurement of blood pressure whereas other modules yield various hemodynamic parameters to obtain beat to beat blood pressure. Linear multivariate equations have been used for this purpose, which have been derived from IPG, PPG and ECG data in 137 subjects aging 10-80 years. Revalidation of these equations has been done in another group of 136 subjects and has yielded a correlation of 82.6% for Systolic Blood Pressure (SBP) and 73.1% for Mean Arterial Pressure (MAP).

Introduction

Blood Pressure (BP) monitoring is important for the management of cardiovascular diseases. The BP of an individual can vary by tens of millimeters of mercury during 24 hours depending on number of factors that include subject's physical activity, mental state, use of medications and condition of internal BP regulatory system.

Continuous and non-invasive arterial BP measurement is desirable for patient monitoring in Intensive Care Units (ICU). It is also desirable for 24 hour ambulatory monitoring; telemedicine; and study on blood pressure variability. Continuous arterial pressure along with ECG has been used in Intensive Cardiac Care Units (ICCU) to improve the automatic diagnosis of cardiac arrhythmias.

IPG and PPG signals have been used in the past to derive Systolic Blood Pressure (SBP), Mean Arterial Pressure (MAP) and Diastolic Blood Pressure (DBP). However the studies have not been consistent and for most of the time the correlation values reported are not in the acceptable range. Most of these investigations have been centered on one or two hemodynamic parameters and few control subjects. Therefore a systematic study was carried out to identify different IPG and PPG parameters that are sensitive to blood pressure values. Subsequently an instrument named "Non-Invasive Blood Pressure Monitor – Beat to Beat" has been developed at ED, BARC, which is discussed here.

The Instrument

The instrument is a versatile hemodynamic monitor comprising a PPG module, an IPG module, an ECG amplifier and an Oscillometric BP module, as shown in Fig. 1. All the signals can be simultaneously acquired and saved in the personal computer.

PPG module comprises a pulse oximeter transducer, current amplifier, photo detector amplifier, sample & hold circuits and amplifier for IR signals. The oximeter transducer has a red light emitter, an infrared (IR) light emitter and a photo sensor, mounted along with the cushion on the inner side. It is energized by the microcontroller through current amplifier. The transmitted photo current is amplified

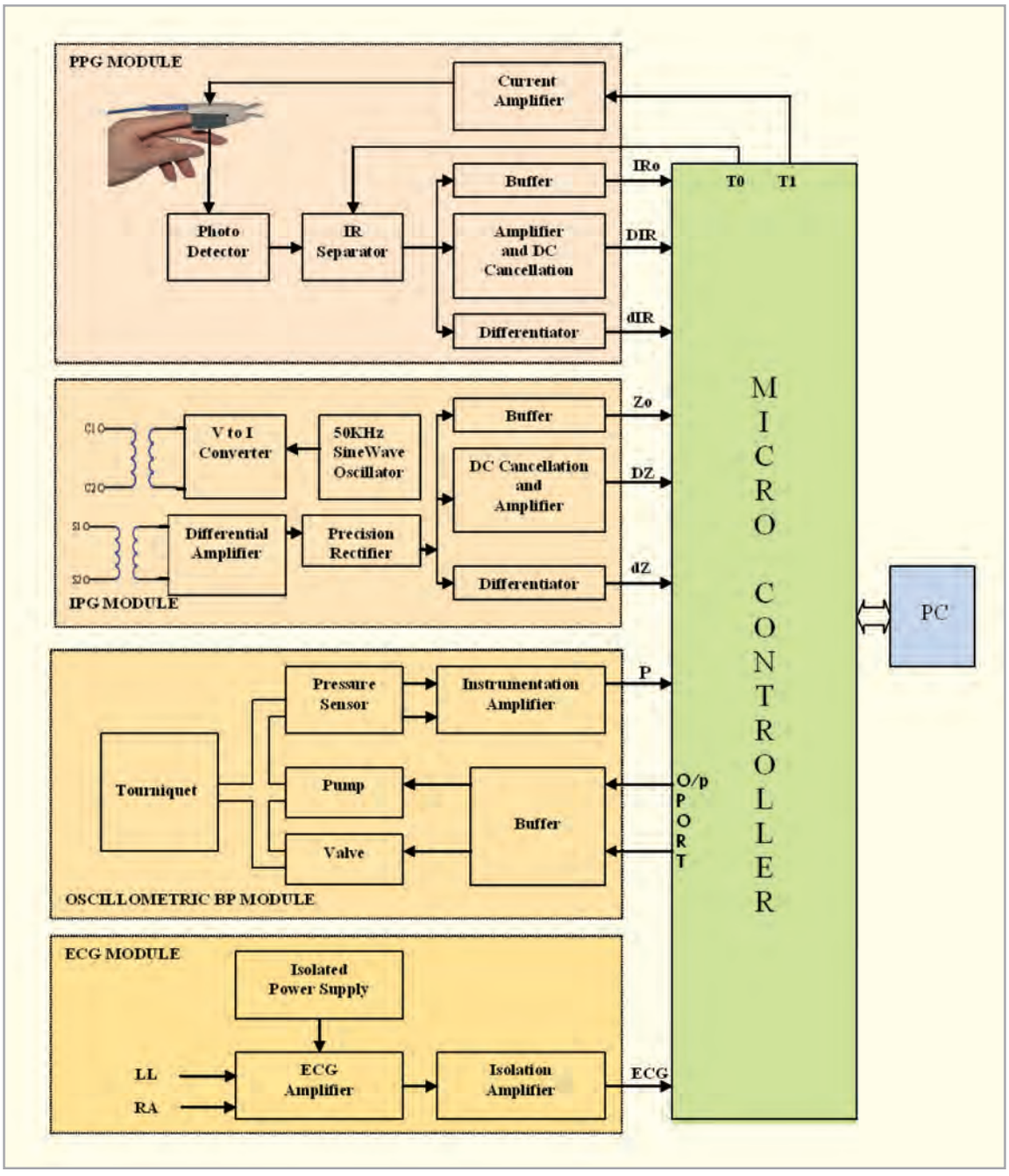

Fig. 1: Schematic block diagram of Non-Invasive Blood Pressure Monitor – Beat to Beat.

and IR signal is separated with the help of timer pulse T_0. This signal is further processed to obtain average transmitted IR intensity (IR_0), change in transmitted IR intensity as function of time (DIR) and rate of change of transmitted IR intensity (dIR).

IPG module comprises a 50 kHz sine–wave generator followed by voltage to current converter. This converter outputs sinusoidal current of constant amplitude 2mA at 50 kHz. This current is passed through the body with the help of two silver plated band electrodes called carrier electrodes (C_1, C_2), placed at neck and left palm. Voltage signal developed along the current path is sensed with the help of another pair of electrodes called sensing electrodes (S_1, S_2), placed 4-5 cm apart on left arm

near axillae. This sensed signal is amplified, filtered and rectified to yield an output signal which is proportional to instantaneous impedance (Z) of the left upper arm segment. The initial value of the impedance (Z_0), also known as basal impedance, is obtained from sample and hold circuit. Small changes in the impedance of the upper arm segment caused by blood circulation are obtained by subtracting the initial value of the impedance from the instantaneous impedance and is called the DZ waveform. Z also differentiated with respect to time to get rate of change of impedance waveform called as dZ waveform.

ECG is recorded in Lead II configuration. For this, the electrical potentials generated by the heart muscle are sensed with the help of two silver/ silver chloride electrodes; positive electrode on the left leg (LL) and the negative electrode on right arm (RA). These signals are connected to pre-amplifier (powered by isolated supply) through protection circuit. The pre-amplifier output is connected to base line restoration circuit in feedback loop. This output is isolated and further amplified to obtain ECG waveform in lead II.

Z_0, IR_0, DIR, dIR, DZ, dZ and ECG signals are interfaced to personal computer using a microcontroller (MSP430 FG4618). Each signal is sampled at 500 Hz frequency. Graphical user interface (GUI) has been developed to save, load and display all waveforms on a single panel as shown in Figure 2. This GUI also has cursor positioning facility to display sample number and its corresponding amplitude in every waveform.

Working Methodology

With the subject in supine, after a rest of 10-15 minutes, Oscillometric BP and Plethysmographic signals were recorded with the help of developed instrument. SBP, MAP and DBP values were measured with help of Oscillometric module. Three sets of readings were taken and two having minimum difference were averaged to yield the reference SBP, MAP and DBP values. Subsequently ECG electrodes were applied at left leg and right

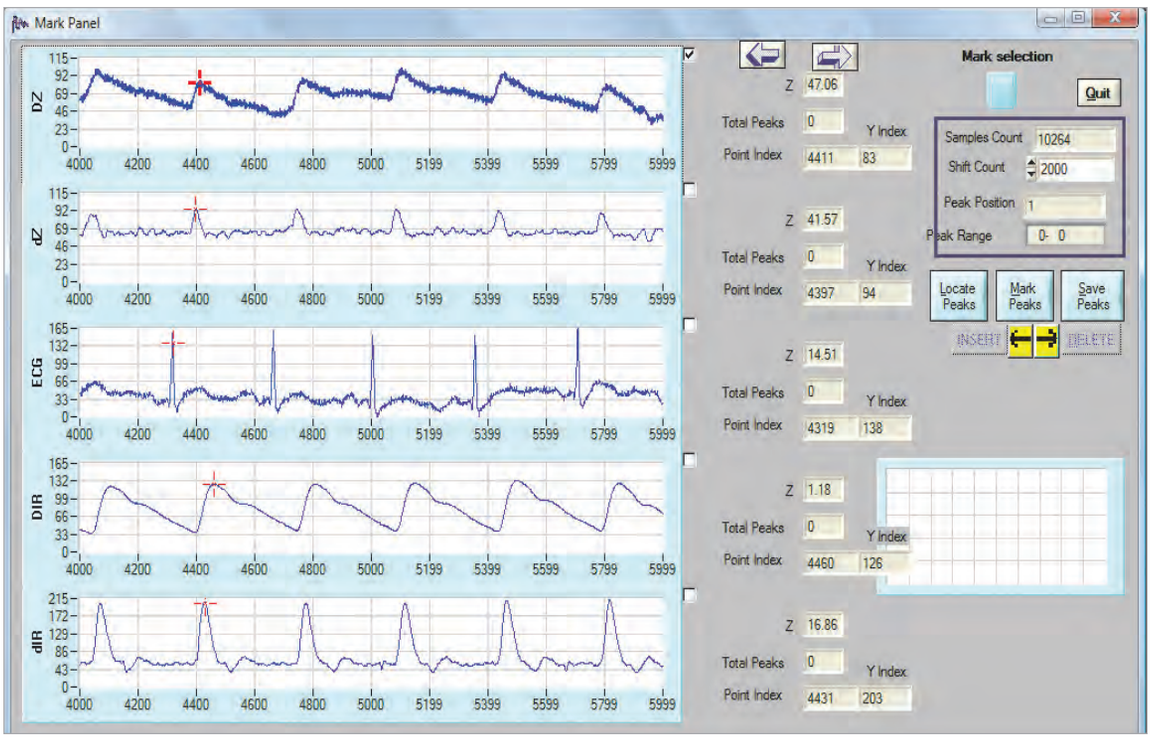

Fig. 2: Display showing simultaneously acquired signals using the developed instrument.

arm; carrier electrodes (C_1, C_2) for IPG were applied at neck and left palm; sensing electrodes (S_1, S_2) for IPG were applied 4-5 cm apart at the left upper arm segment near the axillae; the PPG probe (in the form of clip) was put on the left index finger, as shown in Fig. 3.

Fig. 3: Data acquisition using Beat-to-Beat NIBP Monitor

PPG, IPG and ECG were acquired simultaneously at a sampling rate of 500sps for a period of 50-60 seconds and saved. The study has been carried out in two phases: -

- Phase–I: 137 Indian subjects (94 men and 43 women), in the age group of 10-80 years, including those with hypertension, were randomly selected and were referred as Group-I subjects. Data obtained from IPG, PPG and ECG in Group-I subjects were used for development of prediction equations for SBP and MAP
- Phase-II: 136 Indian subjects (84 men and 52 women) were randomly selected and were referred as Group-II subjects. Observations were used to validate the prediction equations developed during Phase-I study in Group-II subjects.

Since, the study has been exploratory, large number of parameters (given in Table 1) have been derived from PPG, IPG and ECG data of four consecutive cardiac cycles and averaged. This data along with reference blood pressure values in Group-I subjects have been used to obtain the prediction equations.

Statistical analysis has been carried out to obtain descriptive statistics regarding weight (W), age, gender, SBP and MAP in all subjects. The values of 27 predictors (given in Table 1) in Group-I subjects were used to obtain prediction equations.

Stepwise multiple regression analysis has been adopted to develop subject insensitive prediction equations for SBP and MAP from various predictors in recorded waveforms and individual information of Group-I subjects. W, T, G and AG20 (age $\geq$20) have been kept compulsory predictors in each model for the following reasons: -

a) BP is gender and weight sensitive [London et al. 1995] and

b) Subjects under antihypertensive treatment and those aging $<$ 20 years record different morphology of PPG/IPG waveforms.

Optimum model was selected on the basis of minimum value of root mean square errors (RMSE, indicator of SD of error), higher overall correlation coefficient (r) and physiological relevance. The prediction equations obtained for SBP and MAP as above have subsequently been validated on Group-II subjects. Results in Group-II subjects are expressed in terms of correlation coefficient between reference and estimated BP; mean error $\pm$ standard deviation of error; agreement between reference and estimated BP with the help of Bland and Altman plots [Bland and Altman,1986].

Table 1: Predictors used for stepwise multiple regression analysis on Group-I subjects.

Signals	Predictor	Description
PPG	$DIR(t_1)$	Rise time of DIR
	$DIR(t_2)$	Fall time of DIR
	A	Amplitude of DIR pulse
	A/IR_0	Normalized amplitude
	DIR_dIR(p-p)	Time interval between peak of DIR and peak of dIR
	dIR_DIR(p-f)	Time interval between peak of dIR and foot of DIR
	$1/DIR(t_1+t_2)$	Inverse of total time duration of DIR
IPG	$DZ(t_1)$	Rise time of DZ
	$DZ(t_2)$	Fall time of DZ
	AZ	Amplitude of DZ pulse
	AZ/Z_0	Normalized amplitude
PPG-IPG	DIR_DZ (p-p)	Time interval between peak of DIR and peak of DZ
	L/DIR_DZ(p-p)	Pulse Wave Velocity (m/s) measured from peak to peak
	DIR_DZ(f-f)	Time interval between foot of DIR and foot of DZ
	L/DIR_DZ(f-f)	Pulse Wave Velocity (m/s) measured from foot to foot
	dIR_dZ	Time interval between peak of dIR and peak of dZ
	L/dIR_dZ	Pulse Wave Velocity (m/s) measured from dIR and dz
PPG-ECG	$DIR(p)\_R_{ecg}$	Time interval between peak of DIR and R of ECG
	$DIR(f)\_R_{ecg}$	Time interval between foot of DIR and R of ECG
	$dIR(p)\_R_{ecg}$	Time interval between peak of dIR and R of ECG
IPG-ECG	$DZ(p)\_R_{ecg}$	Time interval between peak of DZ and R of ECG
	$DZ(f)\_R_{ecg}$	Time interval between foot of DZ and R of ECG
	$dZ(p)\_R_{ecg}$	Time interval between peak of dZ and R of ECG
Others	T	Under hypertensive treatment
	G	Gender
	W	Weight (kg)
	AG20	Age ≥ 20 years

Results

Descriptive statistics of all the subjects employed in phase-I and phase-II are shown in table 2, SBP and MAP indicated in Table 2 are reference readings obtained by oscillometric method. Prediction equations developed in phase-I for SBP and MAP from Group-I subjects are presented in Table 3.

Predicted SBP and MAP have shown satisfactory correlations with reference measurements ($r = 0.88$, *RMSE* = 6.98, *mean error ± standard deviation of error* = 0 ± 6.77 mm Hg for SBP; and $r = 0.797$, *RMSE* = 7.09, *mean error ± standard deviation of error* = 0 ± 6.88 mm Hg for MAP).

Table 2: Descriptive statistics of all subjects included in the study for developing prediction equations (Phase-I, n= 137) and revalidation (Phase-II, n = 136)

	n	age(years)	W(kg)	SBP(mm Hg)	MAP(mm Hg)
Group-I					
Male	94	36.81 ± 13.74	65.36 ± 16.89	122.9 ± 15.62	90.04 ± 12.4
Female	43	33.44 ± 11.77	57.37 ± 8.66	116.0 ± 9.38	83.70 ± 7.25
Combined	137	35.75 ± 13.2	62.85 ±15.23	120.7 ± 14.3	88.05 ± 11.41
Range	137	10-80	27-110*	85-158	63-126
Group-II					
Male	84	36.98 ± 13.39	66.98 ± 12.97	125.3 ± 13.46	90.68 ± 10.47
Female	52	34.12 ± 13.76	55.40 ± 11.10	112.7 ± 11.04	81.29 ± 8.14
Combined	136	35.88 ± 13.55	62.02 ±13.22	120.5 ± 13.98	87.09 ± 10.65
Range	136	10-80	22-90	88-160	65-113

n = number of subjects; W = weight; SBP = systolic blood pressure; MAP = mean arterial pressure SBP and MAP measured by reference oscillometric method. Groups used for developing the equations (Group-I) and revalidation (Group-II) are totally different; * one of the subject was having weight of 150 kg.

Table 3: Prediction equations for SBP and MAP (Phase-I, n = 137)

SBP = 116 + (17.3 × '*T*' ; = 1 subject on antihypertensive treatment, else = 0) + (1.4 × '*G*' ; male = 1, female = 0) + (0.497× '*W*') – (130 × '*DIR*(t_1)') + (8 × '*DIR_DZ(f-f)*') – (365 × '*dIR_DIR (p-f)*') + (10.8 × '*AG20*'; =1 age ≥20 , = 0 age < 20) + (1.03 × (*'L'/ 'DIR_DZ(f- f)'*))

SBP measured by oscillometric system = 120.7 ± 14.3 mm Hg.

SBP predicted = 120.7 ± 12.59 mm Hg (*r* = 0.88, ***RMSE*** = 6.98, *mean error ± standard deviation of error* = 0 ± 6.77 mm Hg).

MAP= 37.9 + (8.62 × '*T*') + (3.83 × '*G*') + (0.411× '*W*') – (237 × '*dIR_dZ(p-p)*') + (14.1 × 1/ '*DIR*($t_1 + t_2$)') + (8.33 × '*AG20*') – (0.445 × (*'L'/ 'dIR_dZ(p-p)*') + (133 × '*DIR(f)_*R_{ecg}')

MAP measured by oscillometric system = 88.05 ± 11.41 mm Hg.

MAP predicted =88.05 ± 9.095 mm Hg (*r* = 0.797, ***RMSE*** = 7.09, *mean error ± standard deviation of error* = 0 ± 6.88 mm Hg).

Phase-I is development of prediction equations.

Table 4: Comparison of SBP/MAP measured by reference method and estimated by developed equations in Group-II (Phase-II, n= 136)

	Measured by oscillometric method	Predicted by developed equation	*r*	Mean error ± SD of error(mm Hg)
SBP (mm Hg)	120.50 ± 13.98	120.03 ± 12.44	0.826 P < 0.001	-0.47 ± 7.93
MAP (mm Hg)	87.09 ± 10.65	87.28 ± 8.578	0.731 P< 0.001	0.1946 ± 7.3

Phase-II is revalidation of developed equations in phase-I.

These prediction equations have been used to estimate SBP and MAP in Group-II subjects. Table 4 shows the descriptive statistics for these measurements. As can be seen from the Table 4 that estimated SBP and MAP have moderately correlated with reference measurements ($r = 0.826$, *mean error* $\pm$ *standard deviation of error* = -0.47 $\pm$ 7.93 mm Hg for SBP; and $r = 0.731$, *mean error* $\pm$ *standard deviation of error* = 0.19 $\pm$ 7.3 mm Hg for MAP).

Discussions

The studies carried out hitherto have been centered around single parameter derived from ECG and plethysmographic signals on limited number of subjects. The present study is aimed at improving the correlation by including additional parameters on a wider population. In the study of Ye et al., 2010, though the number of subjects is not specified, the correlation of systolic pressure is shown to be 0.8126 in the range of 100-137 mm Hg [Ye et al., 2010]. In comparison present study gives a correlation of 0.826 for systolic pressure ranging between 88-160 mm Hg on 136 subjects aging 10 to 80 years, which is certainly better than the previous attempts.

Thus it appears that plethysmographic parameters that are complementing pulse wave velocity increase the accuracy of SBP and MAP measurement. The predicted results are within the error limits prescribed by Association for the Advancement of Medical Instruments (AAMI) [O'Brien et al., 2002]. According to the AAMI standard, mean error i.e. bias should be $\leq \pm$ 5mm Hg with SD $\leq$ 8 mm Hg [37]. The results of this study show that predicted SBP and MAP during validation phase satisfy the AAMI recommendations [SBP (-0.47 $\pm$7.93) and MAP (0.19 $\pm$7.3)]. Efforts are being made to obtain better DBP estimation.

Acknowledgements

The authors are thankful to Shri G. P. Srivastava, Director, E & I Group, BARC and Shri R. K. Patil, Associate Director (C), E & I Group, BARC; for inspiring us to undertake this development work. The authors also acknowledge the help provided by Smt Gouri V. Sawant and Shri. Ashok D. Kamble during the development and data acquisition.

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Self Assembled Systems: Design and Drug Delivery Perspectives

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Chemistry Division

Abstract

The role of self assembled structures as a drug delivery vehicle has been found for all routes of drug delivery. The efficacy of drug depends on the drug loaded into the vehicle, temperature, drug solubility, pH, release characteristics, additives and most significantly, the vehicle morphology. This in turn suggests that the design of self assembled materials plays a very important role in drug delivery applications. This article provides an overview of the guiding rules for the design of various self-assembled structures such as micelles, worm-like micelles, microemulsions, vesicles and pH-sensitive structures by self assembly approach and their use in therapeutic delivery.

Introduction

In recent years, self assembled materials have received increasing attention in pharmaceutical science as they promise incredible potential for therapeutic and diagnostics applications. Owing to the low aqueous solubility of various drugs, a solubilizing delivery system is often required for reaching sufficient drug bioavailability and/or to facilitate clinical or even preclinical research and development work. Self assembled drug delivery systems, apart from allowing improved solubilization, offer a range of other advantages, including controlled drug release, protection from drug hydrolysis and chemical or enzymatic degradation, reduction of toxicity, and improvement of drug availability. The preparation, characterization and application of materials that are capable of safely and efficiently deliver the drugs to the body of a patient are important challenges in chemical and pharmaceutical sciences. In the present brief overview, we discuss the guiding rules for the design and application of different types of self assembled structures and exemplified with respect to their drug delivery applications.

Self Assembly

Self-assembly involves the spontaneous organization of molecular units into complex heirarchial structures driven by non-covalent interactions. For example, certain amphiphilic molecules, in selected solvents, can self assemble at interfaces and in the bulk in order to isolate their hydrophobic regions from contact with polar solvents. Above a narrow range of concentration, called the 'critical micelle concentration' (CMC), which is characteristic of each solvent-solute system, the amphiphilic molecules associate themselves to form aggregates called micelles. The self-association of surfactants can give rise to a rich variety of phases comprising aggregates such as micelles, vesicles, microemulsions, liquid crystalline dispersions, etc. These phases have a unique structure in which the hydrophilic or hydrophobic compartments with a dimension of a few nanometers are dispersed in a solvent and in most cases it exists in a thermodynamic equilibrium state. These structural features of amphiphilic assemblies make them efficient carriers for the encapsulation of several drug molecules.

Design of self assembled structures

The aggregation of amphiphiles into various structures such as micelles, bilayers, vesicles etc. arise from an interplay of two opposing forces; one the so called 'hydrophobic effect' of the hydrocarbon tails which tends to bring the molecules closer together and the other is the 'solvation' of the head groups which tends to keep the hydrophilic part away from each other. It is found that these aggregate geometries depends broadly on various factors like nature of the surfactant molecule, surfactant concentration, ionic strength of the solution, nature of the counter-ion etc. The geometry of aggregates primarily depends on the dimensionless packing parameter, defined by the ratio $v/a_o l$ (where v is the volume of the surfactant monomer, a_o is the area of the headgroup, and /is the length of the alkyl chain). A lower headgroup area increases the packing parameter of the micelles and this would induce structural transitions in the aggregates. Simple geometrical calculations suggest that when the packing parameter is less than 1/3, spherical micelles are the preferred form of aggregates. Cylindrical micelles form when the packing parameter is between 1/3 and 1/2 and when it is >1/2 highly curved bilayer vesicles are preferred and flat bilayers are formed as it approaches 1. This suggests that the size and shape of the aggregates can be modulated by changing the packing parameter, which in turn depends on the interaction between amphiphiles. Controlling the microstructures of assemblies by tuning the interaction between amphiphiles offers unique opportunities for the design of supramolecular materials for diverse applications. Several surfactant systems have been designed involving ionic as well as nonionic surfactants where structural transitions have been induced in surfactant assemblies by incorporating various additives such as electrolytes, hydrotropes etc that are capable of modulating the packing parameter.

In a cationic surfactant, cetyltrimethylammonium bromide (CTAB) spherical to rod-like micellar transitions have been induced by incorporation of different additives such as an electrolyte sodium nitrate, anionic hydrotropes sodium salicylate (Na-Sal) and sodium p-toluene sulphonate (Na-PTS) etc[1]. These structural transitions have been probed using various scattering techniques (dynamic light scattering (DLS) and small angle neutron scattering

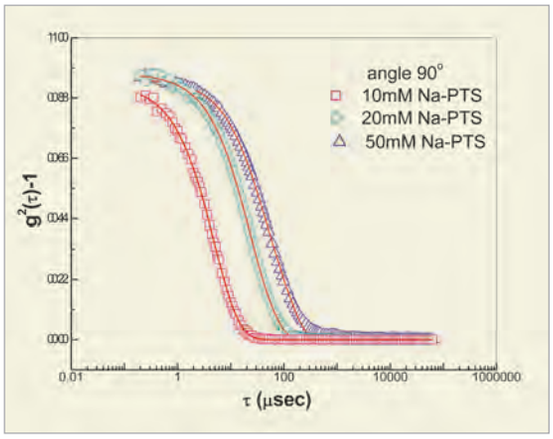

Fig.1: Intensity correlation function of CTAB micelles in presence of different concentration of Na-PTS.

(SANS)). Fig. 1 shows representative plots of intensity correlation function ($g^{(2)}\tau$) (DLS data) for CTAB micelles in presence of different concentration of Na-PTS[1]. The shift of the correlation function to long time with increase in salt concentration is an indication of the growth of the micelles. The diffusion coefficient (D_a) of scattering objects can be obtained by fitting the intensity correlation spectra to appropriate models (solid lines in Fig. 1 are fits to the data using unimodal size distribution). With successive addition of Na-PTS, D_a was found to drop steeply reflecting a sudden increase in the average dimension of the micelles. The observed drastic decrease in D_a can be attributed to the formation of long ellipsoidal micelles. This growth of the mcielles can be explained in terms of the adsorption of the counterions at the surface of the micelles. Due to the oppositely charged nature of the counterions, it decreases the surface charge of the micelles. A decrease in the surface charge density of the micelles decreases the effective repulsion of the headgroups of the surfactants, which, in turn,

reduces the effective headgroup area per surfactant and hence the packing parameter increases. Such changes in the surface charge and consequent growth has also been confirmed from SANS.

Similarly, in an anionic surfactant, sodium dodecylsulphate (SDS), spherical to ellipsoid transition have been observed by incorporation of oppositely charged hydrophobic counterions, such as aniline hydrochloride (AHC), ortho toluidinehydrochloride (OTHC) and meta toluidine

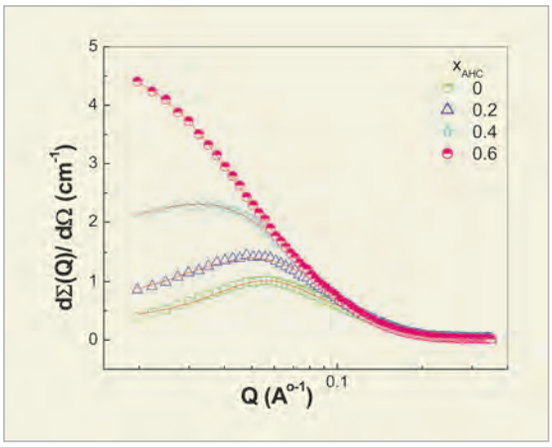

Fig. 2: SANS Spectra of SDS micelles in presence of different concentration of AHC.

hydrochloride (MTHC)[2]. Fig. 2 shows variation in the differential neutron scattering cross section ($d\Sigma(Q)/d\Omega$) with scattering vector (Q) for SDS micelles in presence of different concentrations of AHC. (x_{AHC} = [AHC]/[surfactant]. The solid lines in the figure represent calculated scattering patterns obtained by assuming prolate ellipsoidal micelles.

In the absence of any salt, the SANS spectrum shows characteristic correlation peak indicating the presence of repulsive intermicellar interactions between the negatively charged SDS micelles. With addition of salt, this correlation peak broadens as well as shifts to lower Q values. The broadening of the correlation peak at constant volume fraction of the micelles is an indication of decrease in the range of electrostatic interactions. The shift in Q_{max} towards lower Q value by adding the salt suggests an increase in intermicellar distance. This observation together with the merging of SANS spectra in high Q region for all salt concentrations suggests that the micelles are growing uniaxially with the addition of the salt. The results of quantitative analysis show that the aggregation number as well as the semi-major axis increases upon addition of the salt, while the fractional charge on the micelles decreases.

By changing the nature and concentration of organic counterions it is also possible to induce micelle to vesicle transitions in surfactant assemblies. For example, in a mixture of CTAB and an anionic hydrotrope sodium 3-hydroxy naphthalene 2-carboxylate (SHNC), in the hydrotrope-rich region, dilution induced micelle-vesicle transitions have been investigated using several complementary techniques such as DLS, SANS and rheology[3]. As a model system for pH triggered self assembly, pH-responsive self assemblies were prepared using mixtures of micelles and hydrophobic amino acid mimics[4, 5]. Incorporation of anathranilic acid (AA),

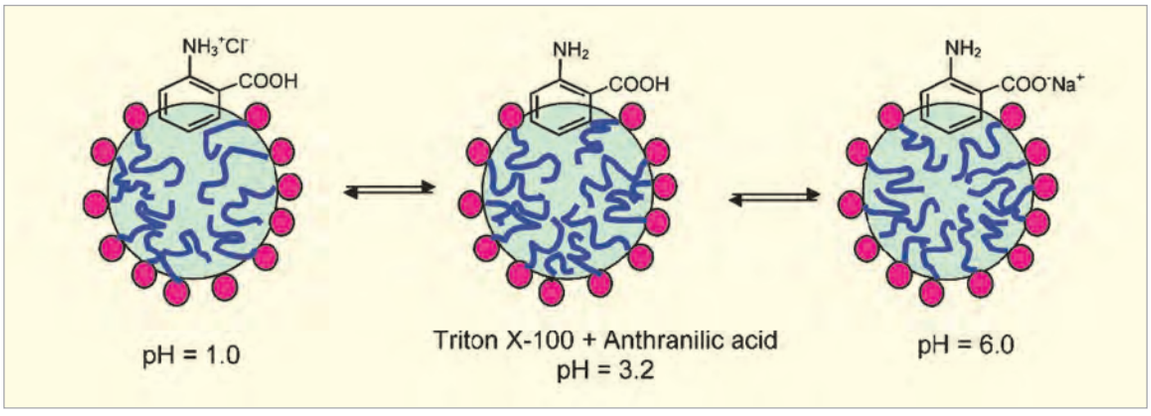

Fig. 3: Charge reversal in nonionic micelles as a function of pH.

a hydrophobic amino acid mimic, into CTAB and Triton X-100 micelles makes them highly sensitive to external pH. Fig. 3 shows a schematic representation of the pH induced surface charge reversal of micelles by adsorbed amino acid molecules. These studies have demonstrated the use of a specific hydrophobic amino acid molecule in forming pH-sensitive assemblies through cooperative self assembly. This strategy can be exploited for preparing novel pH sensitive assemblies that are biocompatible and hence useful for biomedical applications such as drug delivery.

Drug delivery perspectives

Various self assembled structures have been exploited for the sustained delivery of variety of drugs. Micelles as drug carriers provide a set of several advantages. The most important feature of micellar delivery system is their small size (~10 to 30 nm) and the narrow size distribution, which distinguishes them from other particulate drug carriers. The viral like size prevents their uptake by the reticuloendothelial system (RES) and facilitates their extravasation at leaky sites of capillaries by enhanced permeability retention (EPR) effect leading to passive accumulation in certain tissues. The stability of the drug is also increased through micelle incorporation. Micelles as drug carriers physically entrap sparingly soluble pharmaceuticals and deliver them to the desired site of action. Furthermore, since the contact of the drug (by involving micelles as drug carriers) with inactivating species, such as enzymes present in biological fluids, are minimized, in comparison with free drug, the undesirable side effects can be lessened.

The use of mixed micelles for the delivery of anticancer drugs such as doxorubicin hydrochloride (DOX), have been explored using biocompatible surfactants, Tween 80 (T-80) and sodium deoxycholate (NaDC)[6]. Polyoxyethylene groups in T-80 would provide stealth to the micelle evading the reticuloendothelial systems uptake. NaDC being negatively charged was used as a complexing agent to bind with positively charged doxorobucin hydrochloride. The ability of DOX to complex with NaDC was proved from partition experiments which showed that the addition of NaDC increases the hydrophobicity of DOX through electrostatic complexation and can be partitioned completely into the organic phase (chloroform). This complex gets solubilized by the addition of T-80 through mixed micelle formation. This demonstrates the ability of T-80-NaDC mixed micelles to bind model cationic drugs such as DOX. The cytotoxicities of formulations comprising DOX loaded mixed micelles were evaluated in comparison to free DOX and blank mixed micelles on three different human cancer cell lines. The DOX loaded mixed micelles showed 2 to 10- fold lower LC_{50} value as compared to that of plain DOX in various cell lines. This clearly indicates that these mixed micelles not only encapsulate the DOX but also significantly improve anti-cancer activity of DOX in various cancer cell lines. Pluronic micelles have also been employed for physically entrapping anti-cancer drug doxorubicin hydrochloride through the formation of surfactant-drug complex. The binding affinity of doxorubicin within the micelle carrier is enhanced through complex formation of drug and anionic surfactant, Aerosol OT (AOT), which is incorporated in pluronic P123 micelles through hydrophobic interactions. The complexation of anionic AOT surfactant molecule

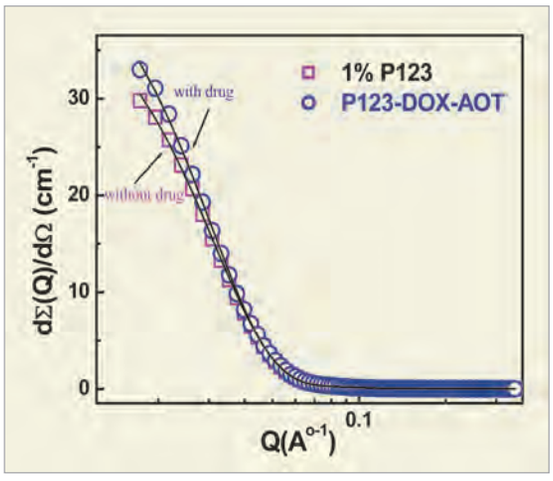

Fig. 4: SANS Spectra of P123 micelles with and without drug.

with cationic drug is confirmed by optical absorption and dynamic surface tension measurements. SANS measurements show no significant changes in the structure of the micelles upon drug encapsulation suggesting that surfactant-drug complexes can be encapsulated in block copolymer micelles without disrupting the structure of aggregates (Fig. 4). Cytotoxicity studies of drug loaded P123 micelles on different human cancer cell lines indicate that the anticancer activity of DOX is not affected by complexation with AOT. In addition to micellar systems, multilamellar vesicles (MLV's) (liposomes) have also been used extensively for drug delivery applications. Stable multilamellar vesicles (onion phases) of the biodegradable surfactant PEG-8 Distearate (PEG8DS) have been prepared for encapsulation of sumatriptan succinate, an antimigraine drug[7]. SANS spectra recorded on the samples of onion phases revealed characteristic patterns of multilamellar vesicles and an increase of inter-bilayer spacing by 7 Å was observed after drug incorporation.

Conclusions

In conclusion, we have demonstrated the strategies to tune the structure and properties of self assembled materials by modulating intermolecular interactions and hence changing the packing parameter of the surfactants. Formulation of pH-responsive self assembled structures without involving any complex synthesis has also been discussed. A variety of self-assembled structures such as micelles, microemulsions, vesicles etc. composed of surfactants and block co-polymers have been shown to be promising candidates for drug delivery applications. We believe that new developments in this area, with enhanced stability of the micelles upon dilution, via cross linking of core or shell of the micelles can lead to intelligent formulations for the delivery of novel therapeutics.

Acknowledgements

The authors are thankful to Dr. D. Das, Head Chemistry Division and Dr. T. Mukherjee, Director Chemiostry Group, BARC for their constant support and encouragement. The Authors gratefully acknowledge the contribution of Dr. V. K. Aswal, SSPD, BARC for helping in carrying out the SANS experiments.

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"The Kroll Zirconium Medal" Award for the year 2012

Dr. Srikumar Banerjee , Homi Bhabha Chair Professor and former Chairman, Atomic Energy Commission has been awarded the prestigious " The Kroll Zirconium Medal" award for the year 2012. The William J. Kroll Zirconium Medal recognizes outstanding achievement in scientific, technological or commercial aspects of zirconium production and utilization. The Kroll award is sponsored and managed by ASTM B10 Committee on Reactive and Refractory metals and alloys. Admiral H.G. Rickover of U.S. Navy, Dr. Antonina V. Nikulina, All-Union Scientific and Research Institute, Russia and Dr. Brian Cox and Dr. Charles Ells, AECL, Canada are among the previous recipients of this Award.

Dr. Banerjee's extensive work encompasses all aspects of phase transformations and provides insights in to the development of microstructure and properties of zirconium alloys during thermo-mechanical processing. His laboratory scale work formed the basis for the flow sheet adopted at the Nuclear Fuel Complex for the manufacture of Zr-2.5Nb pressure tubes for Indian PHWRs.

Dr. Banerjee will receive this award at the 17th International Symposium on Zirconium in the Nuclear Industry to be held in Hyderabad during February 3-7, 2013.

Shanti Swaroop Bhatnagar Prize in Science & Technology 2012

Dr. Sandip Basu, Head, Nuclear Medicine Academic Programme, Radiation Medicine Centre at Bhabha Atomic Research Centre (BARC) in Mumbai has been awarded the Shanti Swaroop Bhatnagar Prize 2012 in Medical Sciences.

The award is named after the Founder Director of the Council of Scientific & Industrial Research (CSIR), the late Dr. (Sir) Shanti Swarup Bhatnagar and is known as the 'Shanti Swarup Bhatnagar (SSB) Prize for Science and Technology'. The Prize is given by the CSIR each year, for outstanding contributions to science and technology. SSB Prizes, each of the value of Rs 5,00,000 (Rupees five lakhs only), are awarded annually for notable and outstanding research, applied or fundamental, in the following disciplines: (1) Biological (2) Chemical (3) Earth, Atmosphere, Ocean and Planetary (4) Engineering (5) Mathematical (6) Medical and (7) Physical Sciences.

Dr. Basu is a pioneer of PET based diagnosis in India and has expanded the application of this methodology for improved patient services. His work focuses on the use of radionuclide therapy and molecular imaging techniques, mainly Fluorodeoxyglucose - Positron emission tomography (FDG-PET) in diagnostics, personalised treatment design and prognostic assessment of cancer and cardiovascular disorders. Dr. Basu has made outstanding contributions in the field of Nuclear Medicine by integrating functional radionuclide imaging and therapy. He has more than 200 peer-reviewed publications to his credit, where he has put forth his ideas, novel concepts and clinical research findings.

Dr. Basu will receive the Award at a formal function, generally presided over by the Prime Minister of India, who is the President of CSIR.

BARC Scientists Honoured

Name of the Scientist	:	**Prof. J.P. Mittal** Distinguished Professor
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Name of the Scientist	:	**Dr. Madangopal Krishnan** Materials Science Division
Award	:	Prestigious DRDO Award for Path Breaking Research / Outstanding Technology Development for 2011
Presented at	:	Kothari Auditorium, DRDO Bhawan, New Delhi on 1st Oct. 2011.

Name of the Scientist	:	**Dr. B.S. Kademani** Scientific Information Resource Division
Award	:	SATKAL National Librarian Award 2012, in recognition of his outstanding contribution to Library and Information Science.
Presented at	:	Punjabi University, Patiala, 6th Nov., 2012

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Edited & Published by:
Dr. K. Bhanumurthy,
Head, Scientific Information Resource Division,
Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India
Computer Graphics & Layout: B.S. Chavan, SIRD, BARC
BARC Newsletter is also available at URL:http://www.barc.gov.in