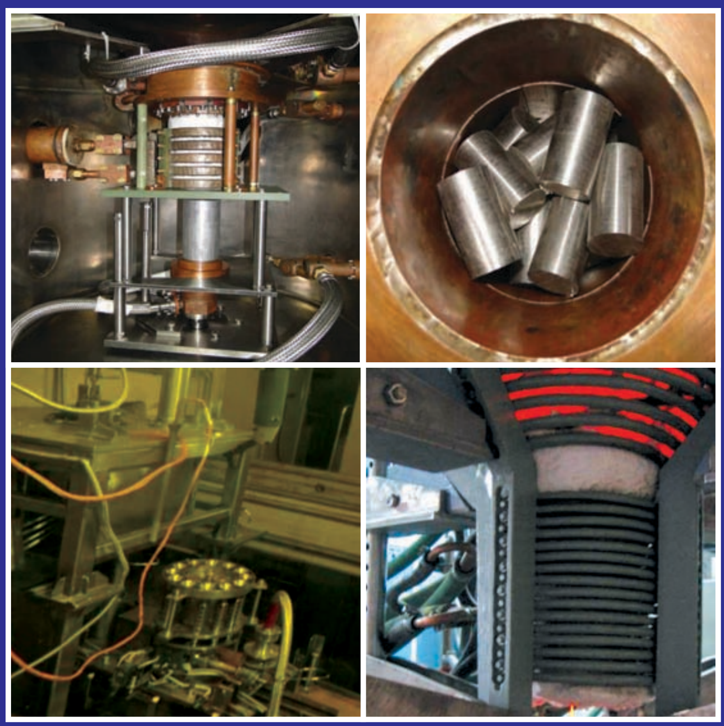
Bi-monthly • November - December • 2015

ISSN: 0976-2108

BARC NEWSLETTER

भाभा परमाणु अनुसंधान केंद्र
BHABHA ATOMIC RESEARCH CENTRE



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संस्थापक दिवस 2015

डॉ. शेखर बसु,
अध्यक्ष, परमाणु ऊर्जा आयोग एवं
सचिव, परमाणु ऊर्जा विभाग के व्याख्यान का संक्षिप्त पाठ

डॉ. होमी भाभा के जन्म की 106वीं वर्षगाँठ मनाते समय भारतीय नाभिकीय कार्यक्रम में गत वर्ष भाभा परमाणु अनुसंधान केंद्र की उपलब्धियों (थोड़े समय पहले ही जिस बारे में मैने जिक्र किया था) के अलावा, मैं कुछ अन्य प्रमुख उपलब्धियों पर प्रकाश डालना चाहूँगा।

भारत में नाभिकीय बिजली संयंत्रों के प्रचालन की जिम्मेदारी वाले न्यूक्लियर पावर कॉर्पोरेशन ऑफ इंडिया लिमिटेड (एनपीसीआईएल) ने वर्ष 2014-15 में लगभग 82% के केपेसिटी फैक्टर तथा 88% की उपलब्धता फैक्टर के साथ 37,835 MUs बिजली का उच्चतम उत्पादन किया। चालू वर्ष में एनपीसीआईएल ने अप्रैल से सितंबर 2015 के दौरान 19118 Mu बिजली का उत्पादन किया।

कुडनकुलम नाभिकीय बिजलीघर संयंत्र की पहली इकाई ने 31 दिसंबर, 2014 को वाणिज्यिक प्रचालन आरंभ किया, जिससे देश की संस्थापित नाभिकीय विद्युत क्षमता 5780 MWe हो गई है। कुडनकुलम स्थित दूसरी यूनिट के अगले वर्ष के प्रारंभ में कमीशन किये जाने की अपेक्षा है।

भारतीय नाभिकीय बिजली संयंत्रों ने लगातार लंबी अवधि का प्रचालन कार्य जारी रखा। इस वर्ष, हमारे नाभिकीय संयंत्रों ने एक वर्ष से अधिक के दो सतत प्रचालन दर्ज किये; नरोरा परमाणु बिजली केन्द्र की यूनिट-2 ने एक वर्ष से अधिक अवधि का सतत प्रचालन दर्ज किया और सितंबर 27, 2015 को 518 दिन की सतत प्रचालन अवधि दर्ज की (योजनाबद्ध शट-डाउन से पहले); कैगा उत्पादन केन्द्र यूनिट-4 ने एक वर्ष से अधिक अवधि तक का सतत प्रचालन दर्ज किया, व 28 जुलाई, 2015 को द्विवार्षिक-शट डाउन के शुरू होने से पहले 419 दिनों का सतत प्रचालन पूरा किया।

500 Mwe प्रोटोटाइप फास्ट ब्रीडर रिएक्टर (पीएफबीआर) का निर्माण कार्य पूरा हो गया है और इसका कमीशनन प्रगति पर है। भाविनि ने चरण-वार कमीशनिंग नामत: सोडियम भरण, ईंधन भरण तथा उसके

बाद क्रांतिकता एवं बिजली का उत्पादन बढ़ाने हेतु नियामक क्लीयरेंसों हेतु एईआरबी के समक्ष आवेदन किया है। द्रुत प्रजनक टेस्ट रिएक्टर (एफबीटीआर) ने इस साल सफल प्रचालन के तीन दशक पूरे कर लिये हैं, और इसे 24.5 MWt और 5MWe के अब तक के सर्वोच्च पावर लेवल पर प्रचालित किया गया, व टर्बो जेनरेटर को ग्रिड से जोड़ा गया।

गुजरात के काकरापार में चार स्वदेशी 700 मेगावाट के दाबित भारी पानी रिएक्टर, काकरापार परमाणु विद्युत परियोजना (केएपीपी 3 एवं 4) की यूनिट (3 एवं 4) एवं राजस्थान के रावतभाटा में राजस्थान परमाणु विद्युत परियोजना (आरएपीपी) के यूनिट -7 और 8 का निर्माण कार्य प्रगति पर है। इन स्थलों में सिविल कार्य तथा विभिन्न घटकों तथा उपकरणों का संस्थापन समानान्तर रूप से प्रगति पर है। इन स्थलों के लिए मुख्य उपकरण की सुपुर्दगी शुरु हो गई है। हमारी सरकार ने कुडनकुलम, तमिलनाडु में रूस परिसंघ (कुडनकुलम नाभिकीय विद्युत परियोजना यूनिट -3 और 4; 2x1000 मेगावाट) के सहयोग से दो साधारण जल रिएक्टर (एलडब्ल्यूआर), गोरखपुर, हरियाणा में दो स्वदेशी दाबित भारी पानी रिएक्टर, गोरखपुर, हरियाणा अणु विद्युत परियोजना यूनिट-1 और 2 ; 2x700 मेगावाट स्थापित करने के लिए अनुमोदन प्रदान कर दिया है।

सरकारी स्वामित्व वाली जनरल इंसुरेंस कॉरपोरेशन-रिइनश्यूरर (जीआईसी -आरई) तथा अन्य कई भारतीय बीमा कम्पनियाँ भारतीय नाभिकीय बीमा समूह (आईएनआईपी) शुरू करने के लिए जून 2015 में साथ में आईं। यह आईएनआईपी नाभिकीय क्षति सिविल देयता (सीएलएनडी) अधिनियम, 2010 के प्रावधानों के अंतर्गत आपरेटर की देयताओं को शामिल करने के लिए शुरूआत में बीमा उत्पाद शुरू करेगी। इस अधिनियम के अंतर्गत आपूर्तिकर्ताओं के जोखिमों को शामिल करने के लिए एक अलग उत्पाद बाद में शुरू किया जाएगा।

प्रत्येक वर्ष भारतीय ईंधन चक्र की विभिन्न सुविधाओं का कार्य निष्पादन उच्चतर स्तरों पर पहुँचना जारी रहा। एनएफसी, हैदराबाद में दाबित भारी पानी रिएक्टर के ईंधन उत्पादन में वर्ष 2014-15 में पिछले वर्ष की तुलना में 30% की वृद्धि हुई।

भारी पानी संयंत्र 100% से अधिक क्षमता उपयोग (111%) सहित अपनी भरपूर क्षमता से आपूर्ति करते रहे तथा पहले की तुलना में सबसे कम विशिष्ट ऊर्जा खपत हुई। भारी पानी बोर्ड के विलायक उत्पादन संयंत्र नाभिकीय ईंधन चक्र के अग्र भाग तथा पश्च भाग की आवश्कताओं को पूरा करने के लिए सफलतापूर्वक प्रचालित किए गए।

एएमडी ने पिछले एक वर्ष के दौरान 14,463t स्वस्थाने U_3O_8 स्थापित किया है जिससे इसका बारहवीं योजना में अब तक कुल योग 50,926t हो गया है। देश के यूरेनियम संसाधन को 1,91,593tU के तद्नुरूप 2,25,936t U_3O_8 तक अद्यतन किया गया है। कुछ स्थानों में कुछ प्रतिकूल स्थिति का सामना करने के बावजूद पहले की तुलना में आज की तिथि तक यूसीआईएल द्वारा यूरेनियम का सबसे अधिक घरेलू

उत्पादन रिकार्ड भी किया गया। प्रति वर्ष 10,000 टन (टीपीए) मोनाजाइट संसाधन संयंत्र का वाणिज्यिक प्रचालन आईआरईएल द्वारा मई, 2015 में शुरू किया गया। आईआरईएल ने अपने ऑस्कॉम यूनिट में एक वर्ष में अपरिष्कृत बालू खनन की अधिकतम मात्रा लगभग 47 लाख टन रिकार्ड की।

ईसीआईएल ने बड़े बंदरगाहों में विकिरण संसूचन उपकरण (आरडीई) का संस्थापन पूरा किया। सतीश धवन अंतरिक्ष केन्द्र में इसरो, श्रीहरिकोटा के लिए ईंधन भरण अनुप्रयोग हेतु क्रमादेशनीय तर्क नियंत्रक प्रणाली की आपूर्ति को भी ईसीआईएल द्वारा पूरा किया गया।

इस वर्ष मार्च में आईएईए के एकीकृत नियामक समीक्षा सेवाएं (आईआरआरएस) मिशन ने परमाणु ऊर्जा नियामक बोर्ड (एईआरबी) के नाभिकीय विद्युत संबंधी नियामक क्रियाकलाप की समस्तरीय समीक्षा की। आईआरआरएस टीम ने एईआरबी की कार्रवाईयों तथा फुकुशिमा दुर्घटना संबंधी समीक्षा की अनुवर्ती कारवाई के रूप में उठाए गए कदमों की प्रशंसा की। हमारे विदेश मंत्रालय के तत्त्वावधान में पऊवि तथा एनपीसीआईएल ने मुम्बई में बांग्लादेश के 35 पेशेवरों के लिए पांच सप्ताह का नाभिकीय ऊर्जा पर फाउंडेशन कोर्स (एफसीएनई) आयोजित किया।

संलयन विज्ञान के क्षेत्र में प्लाज्मा अनुसंधान संस्थान (आईपीआर), गाँधीनगर, गुजरात में स्थिर अवस्था अतिचालक टोकमक (एसएसटी-1) ~ 500 एमएस अवधि तक पुनरावर्तनीय प्लाज्मा निस्सरणों तथा 1.5 तीसला के टोराइडल चुम्बीय क्षेत्र सहित 60 केए से अधिक प्लाज्मा धाराओं के साथ प्रचालित हो गया है। आईटीईआर में भारत की सहभागिता के भाग के रूप में, घरेलू एजेंसी आईटीईआर-इंडिया ने इन-काइंड योगदानों के अपने पहले अवयवों की सुपुर्द कर दी हैं : उच्च ऊष्मा अभिवाह अभिग्राही अवयव पडोवा, इटली के न्यूट्रल बीम टेस्ट फैसेल्टी (एनबीटीएफ) को दिसम्बर, 2014 में तथा न्यूट्रान परिरक्षक ब्लॉक कोरिया की घरेलू अभिकरण को जून 2015 में सुपुर्द कर दिए गए हैं। कूलिंग वॉटर पाइपों की पहली खेप सितम्बर में कडारसे स्थल पर पहुँच गयी है।

कामिनि रिएक्टर अंतरिक्ष मिशन के लिए उत्ताप-युक्तियों की न्यूट्रान रेडियोग्राफी हेतु सफलतापूर्वक प्रचालित किया गया है। पीएफबीआर के लिए भापअकें द्वारा विकसित उच्च तापमान विखण्डन कक्ष का परीक्षण रिएक्टर में भारित विशेष रूप से ऊष्मित कक्ष में 575 सेंन्ट्रीगेड के तापमान तक कामिनि में किया गया है।

आरआरकैट, इंदौर में पऊवि का इन्डस-2 सिंक्रोट्रॉन विकिरण स्रोत 2.5 गीगावाट ऊर्जा तथा 200 एमए धारा तक दिन-रात प्रचालित रहा है। मृद एक्स-रे परावर्तनीय कण पुंज रेखा की कमीशनिंग के साथ इंडस-2 में प्रचालनीय कण पुंज रेखाओं की कुल संख्या बढ़ कर तेरह हो गई है। आरआरकैट अतिचालक रेडियो-आवृत्ति (एससीआरएफ) गुहिकाओं के संविरचन, प्रक्रमण तथा परीक्षण के लिए एक विस्तृत बुनियादी ढांचा स्थापित कर रहा है जो त्वरक चलित प्रणाली तथा समुत्खंडन न्सूट्रान स्रोत पर आधारित भविष्य के बड़ी

नियोबियम गुहिका का सफलतापूर्वक परीक्षण विगत वर्ष के दौरान की मुख्य उपलब्धियों में से एक था।

मूलभूत विज्ञान अनुसंधान तथा कैंसर अनुसंधान के लिए भी क्षमतायुक्त गैसीय संसूचन का प्रगत प्ररूप बेकेलाइट प्रतिरोधी प्लेट चैंबर (आरपीसी) का बड़ा आकार (2.5 एम x 1.25 एम) स्वदेशी रूप से विकसित किया गया तथा वीईसीसी में परीक्षण किया गया ।

भारत ने इस वर्ष (जनरल कांफ्रेंस के सप्ताह के दौरान) आईएईए के वैज्ञानिक फोरम में "उद्योग में परमाणु : विकास के लिए विकिरण प्रौद्योगिकी" विषय पर भाग लिया। भारत के पास इस क्षेत्र में एक विस्तृत कार्यक्रम है तथा यह कई वर्षों तक आईएईए क्षेत्रीय सहयोग करार (आरसीए) कार्यक्रम हेतु उद्योग क्षेत्र में अग्रणी देश रहा है। इस संदर्भ में पऊवि ने अनुप्रयोगों के विकास में स्वदेशी प्रौद्योगिकी क्षमताओं तथा योगदानों को प्रदर्शित करते हुए आईएईए में एक प्रदर्शनी भी स्थापित की।

ब्रिट हेल्थकेअर उत्पादों की विसंक्रमणीयता तथा स्वास्थ्यकारी खाद्य तथा कृषि उत्पादों के लिए उनके सुरक्षित तथा लम्बे समय तक परिरक्षण हेतु विकिरण संसाधन संयंत्रों को स्थापित करने हेतु निजी क्षेत्रों को प्रोत्साहित करता रहा है। वर्ष 2014 में दो नए संयंत्रों, एक उन्नाव, लखनऊ में तथा दूसरा बावला, गुजरात में कमीशनन किया गया।

माननीय प्रधानमंत्री की मंगोलिया यात्रा के दौरान उलानबतर के राष्ट्रीय कैंसर केन्द्र को स्वदेशी टेलीथेरेपी मशीन, भाभाट्रान तथा डिजिटल रेडियोथेरेपी सिमुलेटर (दोनों भापअकें द्वारा विकसित) उपहार के रूप में देने के लिए टाटा स्मारक केन्द्र (टीएमसी) तथा राष्ट्रीय कैंसर केन्द्र, उलानबतर, मंगोलिया के बीच एक समझौता ज्ञापन पर दिनांक 17 मई, 2015 को हस्ताक्षर हुए।

कैंसर प्रबंधन हेतु कम लागत वाले एवं कुशल उपकरणों के विकास की दिशा में सतत प्रयासों के भाग रूप में टाटा स्मारक केन्द्र (टीएमसी) ने आईएईए के सहकार में कैंसर-स्टेजिंग हेतु एक स्मार्ट फोन एप विकसित किया है। TNM (ट्यूमर, नोड, मेटास्टेसिस) को आईएईए महासभा सप्ताह के दौरान आईएईए और वियना स्थित भारतीय दूतावास द्वारा संयुक्त रूप से आयोजित एक समारोह में लांच किया गया था।

नाभिकीय ऊर्जा सहकारिता हेतु वैश्विक केन्द्र (जीसीएनईपी) की पहल के तत्वावधान के अंतर्गत पांच ऑफ-कैंपस पाठ्यक्रम संचालित किये गये। इनमें आईएईए द्वारा चालित रिएक्टर संरक्षा, नाभिकीय सामग्री की सुरक्षा, शारीरिक बचाव आदि पाठ्यक्रम शामिल है।

पऊवि ने वर्ष भर जनता तक आउटरीच एवं जनजागरूकता कार्यक्रमों को बढ़ाने पर विशेष ध्यान दिया। पऊवि द्वारा इसके हीरक जयंती (अगस्त 2014 में शुरू किया गया) समारोह के भाग रूप में विभिन्न स्थानों पर कई कार्यक्रमों का आयोजन किया गया। 2015 के गणतंत्र दिवस परेड में पऊवि का एक झांकी के साथ प्रतिभागिता एक बड़ा आकर्षण था। इसके अलावा स्थानीय भाषाओं सहित विभिन्न भाषाओं में दूरदर्शन

विज्ञापन भी जारी किये गये। पऊवि ने 16 अक्टूबर 2015 में अपने फेस बुक लाँच के साथ हाल ही सोशल मीडिया में भी प्रवेश कर लिया है।

एचबीएनआई जो एक मानित विश्वविद्यालय है (3 जून 2005 से) ने इस वर्ष अपने अस्तित्व के दस साल पूरे किये। एचबीएनआई ने 11 मई 2015 को "ए ग्रेड" विश्वविद्यालय की एनएएसी मान्यता प्राप्त की है।

विभिन्न क्षेत्रों में इन उपलब्धियों को पाने के बाद भी, हमें बहुत कुछ करना बाकी है। नाभिकीय ऊर्जा एवं नाभिकीय अनुप्रयोग दोनों ही क्षेत्रों में नाभिकीय कार्यक्रमों में तेजी लाए जाने की जरूरत है। केकेएनपीपी-2 और पीएफबीआर को शीघ्रत: कमीशन तथा कल्पाक्कम स्थित नाभिकीय पुनश्चक्रण संयंत्रों को भी शीघ्रत: प्रचालनशील किया जाना है। यूरेनियम का उत्पादन बढ़ाया जाना है, और उसके लिए हमें सभी संभावनाओं को तलाशना है। स्वास्थ्य देखरेख तथा स्वच्छ भारत मिशन की सहायता करने हेतु अपशिष्ट प्रबंधन के क्षेत्र में भी ऐसी ही तेजी की जरूरत है।

मुझे विश्वास है कि पऊवि के 29 संस्थानों के मेरे सहयोगी हमारे कार्यक्रम में तेजी लाने हेतु सभी संभव प्रयास करेंगे और अपने विभाग को और ऊंचे पायदान पर ले जाएंगे और डॉ. भाभा के स्वप्न को पूरा करेंगे।

धन्यवाद एवं जयहिंद !

Founder's Day 2015

Address by

Dr. Sekhar Basu

Chairman, Atomic Energy Commission &
Secretary to Government of India, Department of Atomic Energy

Founder's Day Speech by Chairman, AEC 2015 As we celebrate Dr. Homi Bhabha's 106th birth anniversary, I would bring out some of the major milestones achieved in the Indian nuclear programme beyond those at BARC (which I reported a short while ago) during the past year. Nuclear Power Corporation of India Ltd. (NPCIL), responsible for operating nuclear power plants in India, generated 37,835 MUs of electricity the highest ever, in 2014-15, with a Capacity Factor of about 82% and Availability Factor of 88%. In the current year, NPCIL has generated 19118 MUs of electricity during April to September 2015. The first unit of the Kudankulam Nuclear Power Plant, which achieved its first criticality in July 2013, started commercial operations from December 31, 2014, taking the country's installed nuclear power capacity to 5780 MWe. The second unit at Kudankulam is expected to be commissioned early next year. Indian nuclear power plants continue to register records of long continuous runs. This year, two more continuous operation of more than a year of our NPP has been registered: Narora Atomic Power Station Unit-2 registered continuous run of more than a year and completed 518 days on September 27, 2015 (prior to planned shutdown); Kaiga Generating Station Unit-4 registered continuous run of more than a year and completed 419 days of continuous run before start of its biennial shutdown on July 28, 2015. Following the completion of construction of the 500 MWe Prototype Fast Breeder Reactor (PFBR), its commissioning is in progress. BHAVINI has made application for regulatory clearance for the stage-wise commissioning, namely, sodium filling, fuel loading followed by criticality and raising of power.

The Fast Breeder Test Reactor (FBTR), completing three decades of successful operation this year, was operated at the highest ever power level of 24.5 MWt and 5 MWe, with the Turbo Generator synchronized to the grid. Construction work is progressing on four indigenous 700 MW Pressurised Heavy Water Reactors, Units – 3&4 of Kakrapar Atomic Power Project (KAPP 3&4) at Kakrapar in Gujarat and Units-7&8 of Rajasthan Atomic Power Project (RAPP 7&8) at Rawatbata in Rajasthan. The civil works at these sites and erection of various components and equipment are progressing in parallel. Deliveries of key equipment to the sites have commenced.

Our Government has accorded approval for setting up of two Light Water Reactors (LWRs) in collaboration with Russian Federation (Kudankulam Nuclear Power Project Units-3&4; 2X1000 MW) at Kudankulam, Tamilnadu, and two indigenous PHWRs, Gorakhpur Haryana AnuVidyutPariyojanaUnits-1&2; 2X700 MW, at Gorakhpur, Haryana. The State-owned General Insurance Corporation-Reinsurer (GIC-Re) and several other Indian insurance companies came together in June 2015 to launch an Indian Nuclear Insurance Pool (INIP). The INIP will initially launch the insurance product for NPCIL to cover the operator's liability under the provisions of the Civil Liability for Nuclear Damage (CLND) Act 2010. A separate product will be subsequently launched to cover the risks of the suppliers under this Act. The performance of several Indian fuel cycle facilities continues to reach higher levels every year. The PHWR fuel production at NFC, Hyderabad achieved an increase of 30% in 2014-15 over the previous year. Heavy Water Plants continued to deliver their best with over 100% capacity utilisation (111%), and with the lowest ever specific energy consumption. HWB's solvent production plants operated successfully to meet the requirements of nuclear solvents for front-end and back-end of nuclear fuel cycle.

AMD has established 14,463tinsitu U3O8 during the last one year, taking the total to 50,926t in XII Plan period until now and the country's uranium resources has been updated to 2,25,936t U3O8 corresponding to 1,91,593t U. Domestic production of uranium by UCIL also recorded its highest ever production till date, despite facing certain adverse situation in some places. We have made significant strides in augmenting uranium supplies from the foreign sources also. During Hon'ble PM's visit to Canada in April 2015, an agreement was entered into for supply of 3000 tonnes of Uranium ore concentrate. Similar agreement has been entered with Kazakhstan during his visit in July 2015 for supply of 5000 tonnes of uranium over five years. Commercial operation of 10,000 tons per annum (tpa) monazite processing plant was started by IREL in May 2015. IREL recorded maximum quantity of raw sand mining in a year, about 47 lakh tons, in its OSCOM unit. ECIL completed installation of Radiation Detection Equipment (RDE) at major seaports. Supply of Programmable Logic Controller System for fuel loading application at Satish Dhawan Space Centre, for ISRO, Sriharikota was also completed by ECIL. In March this year, the IAEA's Integrated Regulatory Review Services (IRRS) mission conducted the peer review of the nuclear power related regulatory activities of the Atomic Energy Regulatory Board (AERB). The IRRS team appreciated the AERB's actions and the initiatives taken as a follow-up of the Fukushima accident related reviews. Under the aegis of our Ministry of External Affairs, DAE and NPCIL conducted a 5-week Foundation Course on Nuclear Energy (FCNE) in Mumbai for 35 professionals of Bangladesh.

In the field of fusion science, Steady State Superconducting Tokamak (SST-1), at Institute of Plasma Research (IPR), Gandhinagar, Gujarat, has become operational with repeatable plasma discharges up to ~ 500 ms duration and plasma currents in excess of 60 kA with Toroidal Magnetic Field of 1.5 Tesla. As part of India's participation in ITER, the ITER-India, the domestic agency, delivered its first components of in-kind contributions: a high heat flux receiving component has been delivered to the Neutral Beam Test Facility (NBTF) at Padova, Italy in December 2014 and the first batch of Neutron Shield Blocks to Korean domestic agency in June 2015. The first Lot of Cooling Water pipes have reached Cadarache site in September. KAMINI reactor has been successfully operated for neutron radiography of pyro-devices for the space mission. The high temperature fission chambers developed by BARC for PFBR have been successfully tested in KAMINI upto a temperature of 575°C in a specially heated chamber loaded in the reactor. The DAE's Indus-2 synchrotron radiation source at RRCAT, Indore has been operating round the clock at 2.5 GeV energy and up to 200 mA current. With the commissioning of a soft x-ray reflectivity beamline, the total number of operational beamlines on Indus-2 has increased to thirteen. RRCAT is setting up an extensive infrastructure for fabrication, processing and testing of superconducting radio-frequency (SCRF) cavities which are essential elements for the future major projects on Accelerator Driven System and Spallation Neutron Source. One of the major milestones achieved during last year was the successful testing of an indigenously developed five-cell, 1.3 GHz SCRF niobium cavity. Large size (2.5 m. x 1.25 m.) Bakelite Resistive Plate Chamber (RPC), an advanced type of gaseous detector for basic science research, and also with potential for cancer research, has been indigenously developed and tested at VECC.

India participated in the IAEA's Scientific Forum this year (during the week of the General Conference) on the theme' Atoms in Industry: Radiation Technology for Development'. India has a large programme in this area, and has also been the

Lead Country in the Industry sector for the IAEA Regional Cooperation Agreement (RCA) Programme for several years. In this context, DAE did set up an exhibition at IAEA showcasing indigenous technological capabilities and contributions in the development of applications. BRIT has been continuing to encourage private sector to establish

Radiation Processing Plants for sterilisation of healthcare products and hygienisation of food and agro products for their safe and prolonged preservation. Two new plants were commissioned in 2014 one at Unnao, Lucknow and at Bavla, Ahmedabad. A Memorandum of Understanding was signed on May 17, 2015,during the visit of the Honourable Prime Minister to Mongolia, between Tata Memorial Centre (TMC) and National Cancer Centre, Ulaanbaatar, Mongolia for gifting of the indigenous teletherapy machine, Bhabhatron, alongwith Digital Radiotherapy simulator (both developed by BARC) to National Cancer Centre at Ulaanbaatar. As a part of continuing efforts towards the development of cost-effective and efficient tools for management of cancer, the Tata Memorial Centre (TMC), in collaboration with IAEA, has helped to develop a smart-phone App for cancer staging. The TNM App (tumour, node, metastasis) was launched during the week of IAEA General Conference in an event jointly organised by IAEA and Indian Embassy in Vienna. Under the auspices of the Global Centre for Nuclear Energy Partnership (GCNEP) initiative, five off-campus training courses were conducted. They include IAEA Course on Reactor Safety, Nuclear Material Security, Physical Protection etc.

DAE has paid special attention to enhancing public outreach and awareness programmes throughout the year. As a part of DAE celebrating its Diamond Jubilee year (launched in August 2014), a large number of events were held by the various Units of DAE at different locations in their campuses and other places. DAE's participation in the 2015 Republic Day parade with a Tableau was a major highlight, apart from DD advertisements including in regional languages. DAE has recently

made an entry in the social media also, with its launch on Facebook on 16 October 2015. HBNI, a deemed-to-be-University (since June 3, 2005),completed ten years of existence this year. HBNI has received NAAC Accreditation as "A Grade' University on May 11, 2015. In spite of all these achievements in diverse fields, we need to do much more. Nuclear programme needs to be accelerated both in the area of nuclear energy and nuclear applications. KKNPP-2 and PFBR must be commissioned early and nuclear recycle plants at Kalpakkam must be operational earlier. Production of Uranium needs to be increased and for that we need to look at all possibilities. Similar acceleration is required in the area of healthcare and the management of waste to support Swachh Bharat Mission. I am sure all my colleagues in 29 institutions of DAE will do everything possible to accelerate our programmes and take our department to a higher platform and fulfill Dr. Bhabha's dreams. Thank you and Jai Hind.

संस्थापक दिवस 2015

डॉ. शेखर बसु,
भापअ केन्द्र के निदेशक का संबोधन

परमाणु ऊर्जा परिवार के वरिष्ठ सदस्यगण, सम्माननीय आमंत्रित अतिथिगण, मीडिया के प्रतिनिधिगण, मेरे प्यारे सहकर्मियों और साथियों।

मैं संस्थापक दिवस समारोह के लिए आपका हार्दिक स्वागत करता हूं। आज हम सामूहिक रूप से हमारे स्वप्नदृष्टा संस्थापक डॉ. होमी जहांगीर भाभा को उनके 106 वीं (एकसौ छहवीं) वर्षगांठ पर आदरपूर्वक श्रद्धांजलि अर्पित करते हैं।

आज के दिन हम वर्तमान वर्ष में हमारे कार्य निष्पादन और उपलब्धियों को याद करते हैं और भविष्य में अतिरिक्त प्रयास करके और आगे प्रगति के लिए अपने आपको पुनःसमर्पित करते हैं ताकि हमारा राष्ट्र, नाभिकीय विज्ञान और प्रौद्योगिकी के अनुप्रयोगों के माध्यम से लाभान्वित हो।

सबसे पहले मैं आपको इस अवधि के दौरान हमारी कुछ विशिष्ट उपलब्धियों के बारे में बताना चाहूंगा।

मैं विद्युत क्षेत्र तथा अनुसंधान रिएक्टर की कुछ उपलब्धियों से शुरू करता हूं।

पिछले वर्ष आरएलजी में कमीशनन किए गए नए रेडियोसक्रिय प्रकोष्ठ में पीएचडब्ल्यूआर के चार UO_2 ईंधन बंडलों तथा दो MOX ईंधन बंडलों का परीक्षण किया गया। भापअ केंद्र के आरडीडीजी एवं सीजी में विकसित हाइड्रोजन पुनर्योगज को तारापुर के एचआरटीएफ में व्यापक रूप से प्रमाणित किया गया; पीएचडब्ल्यूआर में स्थापित करने के लिए हाइड्रोजन पुनर्योगज के बड़े पैमाने पर विनिर्माण हेतु इस प्रौद्योगिकी को ईसीआईएल को हस्तांतरित किया गया। प्रचालनरत टर्बाइन ब्लेडों की दशा के परीक्षण के लिए भापअ केंद्र में विकसित एक विशेषज्ञ प्रणाली को, भिलाई में प्रचालनरत एनटीपीसी के 250 मेगावाट के विद्युत संयंत्र में क्रियान्वित किया गया। सितम्बर 2014 में, इस प्रणाली ने ब्लेडों के अल्प जीवन की भविष्यवाणी पहले ही कर दी। जनवरी, 2015 में ब्लेड के असफल होने के कारण संयंत्र में एक बड़ी दुर्घटना हो गई जैसा कि इस प्रणाली ने भविष्यवाणी की थी। इस प्रकार, भापअ केंद्र में विकसित इस विशेषज्ञ प्रणाली की सार्थकता प्रमाण के साथ सिद्ध हुई । उच्च प्रवाह

अनुसंधान रिएक्टर हेतु स्टेनलेस स्टील को जर्केलॉय 4 के साथ जोड़ने के लिए एक नवीन गैलेनियम-समर्थित विसरण बंधन तकनीक पर आधारित विधि-तंत्र विकसित की गई।

स्वास्थ्य सेवा क्षेत्र के महत्वपूर्ण विकास कार्य इस प्रकार हैं:-

विकिरण औषध केंद्र के परिसर, संकाय तथा पाठ्यक्रम का निरीक्षण करने के उपरांत भारतीय चिकित्सा परिषद ने वर्ष 2015 से इस केंद्र में नाभिकीय औषधि में एमडी पाठ्यक्रम चलाने की अनुमति दे दी है। नाभिकीय औषध में उच्च-क्षमतायुक्त मानवशक्ति के विकास के लिए यह एक अत्यन्त महत्वपूर्ण उपलब्धि है। पश्च संकरण प्रक्रम सूक्ष्म-व्यूहों तथा झिल्लियों के लिए एक सूक्ष्म प्रवाह प्रक्रमक की एक नई प्रौद्योगिकी विकसित की गई। अनेक प्रकार के कैंसरों सहित अन्य रोगों के विकृतिजनन की पहचान करने हेतु यह स्वचालित, क्रमादेशनीय एवं उच्च पुनरावर्तनीय प्रणाली अत्यन्त उपयोगी है। इस प्रणाली में पुनरावर्ती फैशन में अभिकर्मकों के सब-मिलिलीटर परिमाणों का नियंत्रित प्रवाह होता है। यह नया उपकरण भारत में विकसित अपनी तरह का पहला उपकरण है जिसकी लागत अंतरराष्ट्रीय बाजार की तुलना में लगभग 40% कम है। स्वदेश में अभिकल्पित अल्फा कण किरणक, बीएआरसी बायो अल्फा, का संविरचन, सूक्ष्म मात्रा पर रोगाणुरहित संवर्धन स्थितियों में कोशिकाओं को किरणित करने के लिए किया गया। इसका संविरचन, इसके अन्तर्निहित साफ्टवेयर-अन्तःपाशित (Interlocked) उच्च गति-युक्त शटर गति, प्रयोक्ता-परिभाषित स्रोत गति तथा कॉलिमेटर प्राचलों का प्रयोग करके किया गया और यह कैंसर प्रबंधन में एक सुरक्षित तथा लक्ष्योन्मुखी विशिष्ट चिकित्सीय विधि के रूप में अल्फा कण किरणन के प्रभावी उपयोग हेतु पर्याप्त आंकड़े उपलब्ध कराएगा। इस प्रकार का उपकरण, विश्व में व्यावसायिक रूप में उपलब्ध नहीं है। भापअ केंद्र के भूकंप-विज्ञान प्रभाग ने दिनांक 25.04.2015 को नेपाल में आए भूकंप के भूकंपी संकेत का पता लगाया तथा उसके मूल समय के 17 मिनट के भीतर प्राधिकारियों को इसकी रिपोर्ट दी। गौरीबिदनूर अल्प अवधि एरे (जीबीए) तथा अन्य भूकंपी स्टेशन, दोनों ने, इस घटना का पता लगा लिया।

हम रासायनिकी और रसायन प्रौद्योगिकी के क्षेत्र में नई ऊंचाईयों को छूने में सफल हुए हैं।

राष्ट्रीय संघटनात्मक अभिलक्षणन पदार्थ केंद्र (एनसीसीसीएम) द्वारा विकसित उच्च शुद्धता-युक्त क्वाट्र्ज निर्देशक द्रव्य को भारतीय निर्देशक द्रव्य संख्या बीएनडी 4101.01 प्राप्त हुआ। पऊवि के इतिहास में यह पहला प्रमाणित निर्देशक द्रव्य है जिसे बीएनडी स्टेटस प्राप्त हुआ। खाद्य और लेश-तत्व मात्रा में प्रमुख तत्व की मात्रा की समांगता, स्थायित्व एवं अभिलक्षणन के लिए यूरोपीय आयोग ने एनसीसीसीएम को सेवा प्रदायक के रूप में मान्यता दी है। जर्मेनियम को 9N किलोग्राम स्तर की

शुद्धता तक तैयार करके महत्वपूर्ण उपलब्धि हासिल की गई। यह देश में विकसित अब तक का सर्वाधिक शुद्धता वाला पदार्थ है। बेंच स्केल तरलित संस्तर रिएक्टर में U_3O_8 का प्रयोग संस्तर पदार्थ के रूप में करके 300 ग्राम/लीटर यूरेनियम के सांद्रण पर यूरेनाइल नाइट्रेट विलयन के सीधे विनाइट्रीकरण का निदर्शन किया गया। उत्पाद UO_3 की जांच की गई तथा साइज फ्रैक्शन <53µ को सफलतापूर्वक UF_4 में परिवर्तित किया गया। यह ईंधन चक्र के अग्रांत और पश्चांत पर उत्पन्न होने वाले नाइट्रोजनी बहिःस्राव को काफी हद तक कम करेगा। मार्जक में अवशोषण हेतु पुनर्संसाधन संयंत्र के बहिर्गैस में अनुकारित NOx सांद्रण को ओज़ोन का प्रयोग करके ऑक्सीकृत किया गया। पाइलट संयंत्र स्तर में किए गए निदर्शन से नाइट्रिक अम्ल के रूप में 95% NOx की प्रभावी रूप से पुनर्प्राप्ति की गई। यह ईंधन चक्र के अग्रांत और पश्चांत दोनों के लिए विलयनन के दौरान NOx रिलीज को कम करने में उपयोगी होगा। निजी उद्योग के साथ प्रौद्योगिकी उद्भवन के अंतर्गत, डायमंड इन्डस्ट्री के अनुपयोगी पदार्थ को उपयोगी उत्पाद में परिवर्तित करने के लिए रासायनिक और भौतिक प्रक्रियाएं विकसित की गईं।

उपचार-पूर्व उपाय के रूप में विलायक निष्कर्षण तथा उसके बाद उपयुक्त कांच आव्यूह में सक्रिय घटकों का कांचीकरण करके 20 m^3 लेगेसी उच्च स्तर द्रव अपशिष्ट का प्रबंधन डब्ल्यूआईपी में सफलतापूर्वक पूरा किया गया। पहले सीधे कांचीकरण करने का चलन था जिससे 60 कनस्तर वीडब्ल्यूपी उत्पन्न होता था परंतु अब 20 m^3 उच्च द्रव अपशिष्ट का उपचार करने से केवल 4 वीडब्ल्यूपी कनस्तर उत्पन्न हुआ। रेडियोभेषज अनुप्रयोग के लिए आवश्यक वाहक-मुक्त Y-90 के उत्पादन हेतु उच्च स्तर द्रव अपशिष्ट में से रेडियोरासायनिक शुद्धता वाले Sr-90 को पृथक करने के लिए प्रक्रिया स्थापित की गई। चिकित्सा अनुप्रयोग के लिए रेडियोभेषज अनुभाग को Y-90 की आपूर्ति की गई। अंतरिक्ष कार्यक्रम में Sr-90 के अनुप्रयोग के लिए इसे बड़ी मात्रा में उच्च स्तर द्रव अपशिष्ट में से पृथक करने के लिए भी प्रक्रिया स्थापित की गई।

हमारे हित के कुछ और विकास कार्य इस प्रकार हैं:-

वीएसएससी (इसरो) तथा भापअ केंद्र के बीच एक समझौता ज्ञापन के अंतर्गत त्रिवेन्द्रम स्थित विक्रम साराभाई अंतरिक्ष केंद्र (वीएसएससी) के लिए त्वरक आधारित D-T न्यूट्रॉन स्रोत का प्रयोग करके न्यूट्रॉन रेडियोग्राफी सुविधा स्थापित की गई । भापअ केंद्र के विरल मृदा विकास अनुभाग में उच्च चुंबक-क्रिस्टलीय विषमदैशिक सहित विरल मृदा चुंबकों के स्वदेशी उत्पादन हेतु उच्च क्षेत्र स्पंदित चुंबकन इकाई तथा फील्ड प्रेस मैग्नेटाइजर का विकास और स्थापना की गई।

अब मैं हमारी कुछ विशेष उपलब्धियों का उल्लेख करूंगा जो हमारे इतने सारे सहकर्मियों के प्रयासों से संभव हो पाया।

नाभिकीय पनडुब्बी अरिहंत ने दिनांक 15 दिसंबर 2014 को अपनी पहली समुद्री यात्रा शुरू की और बाद में इसने अपनी पूर्ण शक्ति पर प्रचालन का निदर्शन किया। इसके आगे के समुद्री परीक्षण किए जा रहे हैं और इनकी प्रगति अच्छी है। यह पनडुब्बी, वास्तविक उपयोग के लिए तैयार हो रही है। संहत हल्का पानी रिएक्टर के नियंत्रण एवं यंत्रीकरण प्रणाली के परिनियोजन से पहले एकीकृत परीक्षण और प्रमाणन के लिए भापअ केंद्र के सीएनआईडी में एकीकृत परीक्षण सुविधा (ITF) स्थापित की गई। एक संहत विद्युत-अपघटित्र संयंत्र का विकास किया गया जिसमें कोशिका मॉडयूल और प्रक्रम स्किड शामिल है। इसका उपयोग नाभिकीय पनडुब्बी के लिए जीवन सहयोगी प्रणाली के रूप में किया जाएगा। दिनांक 29 नवंबर 2014 को ध्रुवा रिएक्टर को उसकी पूर्ण शक्ति 100 मेगावाट पर प्रचालित करना शुरू किया गया। इस रिएक्टर ने अगस्त 2015 में अपनी क्रांतिकता के 30 वर्ष पूरे किए। तब से यह उच्चतम क्षमता गुणांक तथा न्यूनतम ईंधन विफलता दर प्राप्त करता रहा है। संयंत्र अच्छी तरह चल रहा है और इसने उच्च विशिष्ट गतिविधि वाले रेडियोआइसोटोपों का रिकार्ड मात्रा में उत्पादन किया। ईंधन संविरचन सुविधाओं ने उच्च क्षमता गुणांक पर सतत प्रचालन हेतु ईंधन की समयबद्ध आपूर्ति सुनिश्चित की। विशेष ईंधन असेम्बली का किरणन शुरू किया गया। अक्तूबर 2014 में नई सुविधा का निर्माण प्रारंभ किया गया तथा शेष गतिविधियों के लिए ठेके दिए जा रहे हैं। इस सुविधा के लिए अपेक्षित एलुमिनियम आव्यूह में LEU आधारित U_3Si_2 प्लेट तथा मिश्रधातु में क्लैड भी बनाया गया। डीडीयू बंडलों को काटकर इसका विघटन करके कलपाक्कम में P3A का तप्त कमीशनन शुरू किया गया। संयंत्र के सभी क्षेत्रों में कमीशनन गतिविधियां पूरे जोर से चल रही हैं। भापअ केंद्र, थोरिया आधारित प्रणाली के लिए पूर्ण ईंधन चक्र के विकास पर कार्य कर रहा है। दिनांक 12 जनवरी 2015 को विद्युत रिएक्टर थोरिया पुनर्संसाधन सुविधा (PRTRF) का सक्रिय कमीशनन शुरू होने से इस कार्य को अत्यधिक बढ़ावा मिला। इससे हम थोरिया आधारित पुनर्संसाधन गतिविधि के अग्रणी बन जाएंगे। तारापुर स्थित प्रीफ्रि-2 तथा कलपाक्कम स्थित कार्प, इन दोनों पुनर्संसाधन संयंत्रों का उत्तम निष्पादन जारी रहा। इन संयंत्रों ने वर्ष 2014 में अब तक का सर्वोत्तम निष्पादन किया तथा इस वर्ष भी ऐसे ही निष्पादन की आशा है। तारापुर के अपशिष्ट निश्चलीकरण संयंत्र ने भी वर्ष 2014 में अच्छा निष्पादन करके 120% क्षमता पर कार्य किया। यह अब तक का रिकार्ड है और इस वर्ष भी इसका निष्पादन उतना ही अच्छा हो रहा है। 'उच्च तीव्रता वाले प्रोटॉन त्वरकों हेतु भौतिकी एवं प्रगत प्रौद्योगिकी' परियोजना के लिए सरकार का अनुमोदन प्राप्त किया गया तथा सहयोगी व्यवस्था के ब्यौरे तैयार किए गए हैं। भारतीय वैज्ञानिकों का पहला बैच, फर्मीलैब संयुक्त अभिकल्पन गतिविधियों के लिए प्रस्थान कर चुका है। भारत में विकसित उपकरण का टेस्ट ट्रायल यूएसए के फर्मीलैब में किया जा रहा है। आदिप्ररूप द्रुत जनक रिएक्टर के लिए ईंधन पिनों की आपूर्ति पूरे जोर पर रही।

रिएक्टर क्रोड के लिए 90% ईंधन पिनों का संविरचन किया जा चुका है। ट्रांबे में 73 स्रोतों का उपचार करके ऑर्फन रेडियोसक्रिय स्रोतों का निपटान प्रारंभ किया गया। यह प्रकिया जारी रहेगी। हम एईआरबी द्वारा एकत्र किए गए सभी स्रोतों का उपचार करने की तैयारी कर रहे हैं। मुंबई स्थित टीआईएफआर की पेलेट्रॉन लाइनेक सुविधा में भारतीय राष्ट्रीय गामा एरे (आईएनजीए) स्पेक्ट्रममापी का प्रयोग करके नाभिक ^{188}Pt का उच्च स्पिन स्पेक्ट्रमदर्शिकी अध्ययन करने से शेप और हाई-आइसोमेरिक दोनों अवस्थाओं के विरल और असामान्य सह-अस्तित्व होने के बारे में पता चला। भापअ केंद्र अस्पताल में चिकित्सकों और कर्मचारियों द्वारा किए गए विशेष प्रयासों से गैर-आपातकालीन मामलों के लिए अपॉइन्टमेन्ट लेने की प्रतीक्षा सूची अवधि को कम करके दो सप्ताह से भी कम किया गया। स्वदेश में विकसित नवीन विलायक निष्कर्षण प्रक्रिया का प्रयोग करके लेगेसी उच्च स्तर द्रव अपशिष्ट (एचएलएलडब्ल्यू) में से बड़ी मात्रा में सीजियम-137 को अलग करना शुरू किया गया तथा कांचीकृत Cs-137 पेन्सिल स्रोतों की दस पेन्सिलों के पहले सेट का संविरचन करके इसकी आपूर्ति की गई। इन पेन्सिलों का प्रयोग ब्रिट के रक्त किरणक में किया जा रहा है। इस प्रौद्योगिकी का प्रयोग, व्यावसायिक क्षेत्र में विश्व में पहली बार किया जा रहा है। आगे भी उत्पादन गतिविधि जारी है। पुनर्संसाधन संयंत्र से निकले अवक्षयित यूरेनियम का उन्नयन पहली बार किया गया। कलपाक्कम स्थित डब्ल्यूआईपी में यूरेनियम पृथक्करण संयंत्र का तप्त कमीशनन किया गया तथा उच्च स्तर अपशिष्ट में से यूरेनियम का पृथक्करण और अपशिष्ट का परिमाण और कम किया गया। कार्प की एक भंडारण टंकी में से उच्च स्तर अपशिष्ट का उपचार किया गया। कार्प की आईएलडब्ल्यू टंकियों को खाली किया गया। भापअ केंद्र ने ईसीआईएल के सहयोग से सुवाह्य एक्स-किरण सामान निरीक्षण प्रणाली (पीएक्सबीआईएस) का अभिकल्पन और विकास किया है। हवाई अड्डे, रेल्वे स्टेशन जैसे सार्वजनिक स्थानों पर सुरक्षा आवश्यकताएं पूरी करने के लिए इसका प्रयोग किया जाएगा। यह उपकरण आयातित उपकरण से सस्ता भी है। विशेष क्लैडिंग पदार्थ का विकास कार्य पूरा किया गया तथा आईएफ3 में इसका उत्पादन जारी रहा। विशेष पदार्थ उत्पादन की सभी सुविधाएं बहुत अच्छा कार्य निष्पादन करती रहीं। स्वदेश में निर्मित पाइलट संयंत्र में पहली बार 4.5^0 U पर द्रव हीलियम का उत्पादन किया गया। प्रोटॉन कणपुंज को निम्न ऊर्जा उच्च तीव्रता वाले प्रोटॉन त्वरक (LEHIPA) में पहली बार 1.2 Mev तक त्वरित किया गया। जब यह पूरी हो जाएगी तब यह विश्व में सबसे अधिक ऊर्जा उत्पादन करनेवाली सुविधा बन जाएगी।

प्रिय साथियों,

हमारे केंद्र की ये सभी उपलब्धियां हमारे उन साथियों की बदौलत संभव हो पाई जिन्होंने परदे के पीछे रहकर कार्य किया। मैं विशेष रूप से प्रशासन, लेखा, स्वास्थ्य देखरेख, अग्निशमन सेवा, इंजीनियरी

सेवा, संरक्षा, एसोसिएशन/यूनियन और अन्य क्षेत्रों को धन्यवाद देना चाहता हूं जिन्होंने हमारी प्रगति और उपलब्धियों को संभव बनाया।

अपना भाषण समाप्त करने से पहले मैं सूचित करना चाहता हूं कि शोकसंतप्त परिवार के लिए भापअ केंद्र परिवार राहत योजना सहायता की राशि को 1.3 लाख रूपये से बढ़ाकर 1.5 लाख रूपये की जा रही है।

जैसा कि आप सबने ध्यान दिया होगा कि पिछले कुछ वर्षों में हमने अपने उत्पादों और सेवाओं को उपयोग के लिए उपलब्ध कराने में अच्छी खासी उन्नति की है। यह इसलिए संभव हो पाया क्योंकि हमारा लक्ष्य राष्ट्र की सेवा करना है। हमने पिछले कुछ समय से चल रही गतिविधियों को पूरा करने में सराहनीय उपलब्धियां प्राप्त की हैं। हमने अनेक महत्वपूर्ण सुविधाओं की कार्यकुशलता में भी सुधार किया है।

औषधियों का विकास, उच्च प्रौद्योगिकी अनुसंधान सुविधाओं का निर्माण, आदि में नए पहल किए गए हैं।

इन उपलब्धियों की सराहना के साथ-साथ हम सब इस बात से सहमत हैं कि हमें अपनी गतिविधियों के सभी क्षेत्रों में आगे और भी अधिक प्रयास करके अधिक से अधिक कार्य करने हैं।

यद्यपि ऐसे कुछ क्षेत्र हैं जिनमें अच्छी प्रगति नहीं हो रही हैं लेकिन इसके कारण हमारे नियंत्रण से परे हैं परंतु कुछ अन्य क्षेत्रों में डिलीवरी में सुधार करने की ओर ध्यान केंद्रित करने की आवश्यकता है।

हमारे लिए आज का दिन इस बात के लिए सर्वथा उपयुक्त है कि हम अपने कार्य तथा अपनी सेवाएं उपलब्ध कराने में और अधिक तेजी लाने के लिए अपने आपको पुनः समर्पित करें।

जय हिंद ।

Founder's Day 2015

Address by

Dr. Sekhar Basu
Director, BARC

Senior Members of the DAE Family, Distinguished Invitees, Representatives from Media, my dear Colleagues and Friends, I extend warm welcome to all of you to this Founder's Day functions. Today, we will collectively pay respectful homage to our visionary Founder, Dr. Homi Jehangir Bhabha, on his 106th birth anniversary. This is a day on which we reflect on our performance and achievement in the current year and also rededicate ourselves for further improvement with extra efforts so that our nation benefits from the applications of nuclear science and technology.

To begin with let me tell you about some of the specific achievements during this period.

I start with some of the achievements in power and research reactor sectors. Four UO2 fuel bundles of PHWR and two MOX fuel bundles of PHWR were examined (PIE) in the RLG's New Hot Cell Facility commissioned last year. The hydrogen recombiner developed at BARC has been extensively qualified at HRTF, Tarapur. Technology for large-scale manufacture of the hydrogen recombiner for installation in PHWRs has been transferred to ECIL. An expert system developed by BARC for health monitoring of operating turbine blades was implemented on NTPC`s 250 MWe power plant operating at Bhilai. In September 2014, the system predicted in advance, short life, for the blades. In January 2015, the plant experienced a major accident due to blade failure as predicted by the system, in turn providing a major endorsement and validation of the expert system developed at BARC.

A methodology for joining stainless steel to Zircaloy 4, based on a novel Ga-assisted diffusion bonding technique, was developed for High Flux Research Reactor. Notable developments in the health care sector are:- RMC has been recognized for conducting MD (Nuclear Medicine) course from 2015 by the Medical Council of India, following an inspection of premises, faculty and curriculum. This is a very important achievement for high-calibre manpower development for nuclear medicine.

A new technology of a Micro-flow Processor for post-hybridization processing microarrays and membranes has been developed. This automated, programmable and highly repeatable system with controlled flow of sub-millilitre volumes of reagents in an iterative fashion is very useful in identifying pathogenesis of diseases including various types of cancers. The new instrument is the first of its kind developed in India with a cost reduction by about 40%, compared to that in the international market. An indigenously designed Alpha particle irradiator, BARC Bio Alpha, has been fabricated to irradiate cells under sterile culture conditions at a precise dose using its built-in software-interlocked high speed shutter speed, user-defined source speed and collimator parameters and will provide adequate data for effective use of Alpha particle irradiation as a safe and target-specific therapeutic mode in cancer management. Such instrument is not commercially available in the world. Seismology Division of BARC detected seismic signal from Nepal earthquake event on 25.04.2015 and reported it to the authorities within 17 minutes of the origin time. They also reported the event in Hindu Kush region of Afghanistan in short time.

We have been able to reach new heights in the field of chemistry and chemical technology. High purity quartz reference material developed by National Centre for the Compositional Characterization of Materials (NCCCM) has received the Indian Reference Material Number BND 4101.01. This is the first certified reference material from DAE to receive the BND status. NCCCM has been validated as a (service) supplier by European Commission for homogeneity, stability and characterization of major element content and trace element content in food. In the ultra-purification of germanium, another landmark was achieved by preparing 9N material at kg level. This is the highest purity material developed in the country.

The direct denitration of uranyl nitrate solution (at conc. of 300 gm/l of U) was demonstrated in bench scale fluidized bed reactor using U3O8 as bed material. The product UO3 was screened and size fraction $<53\ \mu$ was successfully converted into UF4. This will considerably reduce nitrogenous effluent generation at front and back end of fuel cycle. Simulated NOx concentration in the off-gas of reprocessing plant was oxidised using ozone for absorption in scrubber. The demonstration carried out in pilot plant level could effectively recover 95% of NOx as nitric acid. This will be useful in reduction of NOx release during dissolution both for front and back end of fuel cycle. Chemical and physical processes for converting diamond industry waste into useful product were developed under technology incubation with a private industry. In the field of waste management our team at Trombay did commendable job.

Management of 20 m3 of legacy High Level Liquid Waste has been successfully completed at WIP using solvent extraction as pre-treatment step followed by vitrification of active components in suitable glass matrix. Only 4 VWP canisters have been generated, for the treatment of 20 m3 of HLW, as compared to 60 canisters in case of direct vitrification which was practised earlier. Process for separation of Sr-90 of radiochemical purity from High Level Liquid Waste has been established for generation of carrier free Y-90 required for radiopharmaceutical applications. Y-90 has been supplied to Radiopharmaceuticals Section for medical application. Process for separation of bulk quantity of Sr-90 from High Level Liquid Waste for its application in space programme has also been established.

Some other developments of interest are:- Neutron Radiography Facility using accelerator based D-T neutron source for Vikram Sarabhai Space Centre (VSSC), Trivandrum, has been commissioned under VSSC (ISRO) - BARC MOU. A high field pulsed magnetization unit and field press magnetiser for indigenous production of rare earth magnets with high magneto-crystalline anisotropy has been developed and installed at Rare Earth Development Section of BARC. Let me now mention some of our special achievements, made possible by the efforts of large number of my colleagues. Nuclear Submarine 'Arihant' started its first sea voyage on December 15, 2014 and subsequently demonstrated operation at full power. Further, sea trials are progressing well and the boat is getting ready for induction. For integrated testing and qualification of C&I systems of compact LWR, an Integrated Test Facility (ITF) has been set up at CnID, BARC. A Compact Electrolyser Plant, consisting of cell module and process skid, has been developed for use as a life support system for nuclear submarine. On 29th November 2014 DHRUVA reactor was taken to its full power, 100 MWth. The reactor completed 30 years of its criticality in August 2015. Since then it has been achieving highest ever capacity factor and lowest ever fuel failure rate. Plant is operating fine and produced record amount of radioisotopes of high specific activity. Fuel fabrication facilities ensured timely supply of fuel for continued operation at high capacity factor. Irradiation of special fuel assembly was started.

Construction of new facility was started in October 2014 and contract is being awarded for the balance activities. LEU based U3Si2 plates in aluminium matrix and clad in Alloy required for this facility was also made. Warm commissioning of P3A at Kalpakkam was started with the chopping of DDU bundles. Commissioning activities are progressing in full swing in all the areas in the plant. BARC is working on the development of complete fuel cycle for Thoria based system. It got a major boost with the active commissioning of Power Reactor Thoria Reprocessing Facility (PRTRF). This step will take us to the forefront of Thoria based reprocessing activity. Reprocessing plant PREFRE 2 at Tarapur and KARP at Kalpakkam continue to give excellent performance. Both these plants gave their best ever performance in 2014 and is expected to do well this year also.

Waste Immobilization Plant at Tarapur also worked as well in 2014 and set all time record by working at 120% capacity. The plant continues to perform equally well this year. Government approval for the project 'Physics and Advanced Technologies for High Intensity Proton Accelerators' was obtained and details of collaboration arrangement has been worked out. First batch of Indian scientists have proceeded to Fermilab joint design activities. Equipment developed in India are undergoing test trials at Fermilab, USA. Supply of fuel pin for Prototype Fast Breeder Reactor was continued in full swing. 90% fuel pins for the core has been fabricated. Disposal of orphan radioactive sources was started with the treatment of 73 sources in Trombay. The process will be continued and we are preparing to treat all the sources that are collected by AERB.

A high-spin spectroscopic study of the nucleus 188Pt using the Indian National Gamma Array (INGA) spectrometer at the Pelletron Linac Facility at TIFR, Mumbai, has revealed the rare and unusual coexistence of both shape- and high- isomeric states. Special efforts made by doctors and staff in BARC hospital has brought down the waiting list for appointment in non-emergency cases to two weeks. Separation of large quantity Cesium-137 from legacy High Level Liquid Waste (HLLW) using indigenously developed novel solvent extraction process was established and fabrication and delivery of the first set of ten pencils of vitrified Cs-137 pencils took place. These pencils are being used in BRIT's Blood Irradiator. This technology is being used for the first time in the world in commercial domain. Further production activity is continued. Depleted uranium from reprocessing plant was used for the first time for upgradation.

At WIP Kalpakkam Uranium Separation Plant was hot commissioned and separation of Uranium from HLW and further volume reduction was carried out. HLW from one storage tank of KARP has been treated. The ILW tanks at KARP were emptied. BARC has designed and developed Portable X-ray Baggage Inspection System (PXBIS) in collaboration with ECIL. This product will now serve the security needs at public places like airports, railway stations as a low-cost substitute for imported instrument. Special cladding material development was completed and production at IF3 continued. All special material production facilities continued to perform very well. Liquid helium was produced at 4.50 K for the first time in a pilot plant made indigenously. This is a big step forward for Cryogenic Technology Development.

Proton beam was accelerated to 1.2 Mev at Low Energy High Intensity Proton Accelerator (LEHIPA) for the first time. It is one of the milestones for ADSS programme in India. Dear Colleagues, All these achievements of BARC were possible because of our unsung heroes, who work behind the scene. My special thanks to administrative, accounts, health care, fire services, engineering services, security, association/union and several other areas, that made all our progress and achievements possible. Before concluding I wish to inform that the BARC Family Relief Scheme support to the bereaved family is being increased from Rs.1.3 lakh to Rs.1.5 lakh.

As you would have noted that over the last few years there is considerable improvement in our delivery, which has been possible

because of our focus on serving the nation. We have made commendable achievements in completing activities which are going on for some time and also achieved remarkable improvement in the functioning of various critical facilities. New initiatives have been taken in the development of medicines, creation of high technology research facilities, etc. While acknowledging these achievements we must agree that we have to do much more in the other spheres of our activities. Although some of the areas in which progress is not good are attributable to reasons beyond our control but in other areas we need to do focus for improvement of delivery. For us today is the right day to rededicate ourselves to accelerate the pace of delivery at an early date.

Jai Hind

27th All India Essay Writing Contest

The 27th DAE All India Essay Contest on 'Nuclear Science and Technology' was held in October 2015. A total of 307 essays were received, out of which the authors of 29 essays were selected for making an oral presentations at Mumbai. The selected participants visited various DAE facilities such as BARC, TAPS-3&4, BRIT, EBC etc. Prizes, in cash were awarded on Founder's Day which was celebrated on October 29, 2015 at BARC.

Essays were invited on the three following themes:

Theme 1: Demand for safe, clean and reliable energy in India; Role of Nuclear Power

169 essays were received on this theme out of which 154 were in English, 13 in Hindi and 1 each in Tamil and Gujarati. 12 essays were shortlisted from this category.

Theme 2: Radioisotopes and Radiation Technologies for the welfare of mankind; A Saga of 120 years

101 essays were received on this theme out of which 100 were in English and 1 in Tamil. 12 essays were shortlisted from this category.

Theme 3: Power Beams and their Applications in Energy, Environment and Healthcare

37 essays were received on this theme out of which 36 were in English and 1 in Hindi. 5 essays were shortlisted from this category.

Participants of the 27th DAE All India Essay Contest visiting various DAE facilities

Industrial Safety Awards 2014

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

The entries from the various Divisions/Sections/ Units of BARC for the year 2014 were invited from 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 were 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.

During the Founder's Day Programme held at the Central Complex Auditorium, BARC on 30.10.2015, Shri R.J. Patel, Chairman, CFSRC and Chairman, Industrial Safety Award Scheme Committee announced the winning units for the year 2014. The winning units are:

A. Under Category "Operating Plants " Tarapur Reprocessing Plant (TRP) [PREFRE-I, PREFRE-II, AWTF, SFSF]

B. Under Category "R&D Labs and Industrial Units" Ion Accelerator Development Division (IADD), 6MV FOTIA

C. Under Category "Engineering, Projects and Support Units" Nuclear Recycle Project Construction (INRPC), NRB, Tarapur

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

Shri S. Pradhan, Chief Superintendent, TNRPO, and Shri K Dubey, Plant Superintendent, TRP and Shri Hemant Kumar, Safety Coordinator, TRP received the award in Category A - Operating Plants.

Shri P.V. Bhagwat, Head, IADD, Shri S.K. Gupta, Head, FOTIA Section, IADD and Shri Arun Agarwal, Safety Coordinator, IADD received the award in Category B: R & D Labs and Industrial Units.

On behalf of Integrated Nuclear Recycle Project Construction (INRPC), NRB, Tarapur Shri K.K.Singh, Project Director, INRPC and Shri M. Domesa, Safety Coordinator, INRPC, Tarapur received the award in Category – C Engineering, Projects and Support Units.

Category A: Operating Plants – Safety Award received by Shri S. Pradhan, Chief Superintendent, TNRPO accompanied by Shri K.Dubey, PS, TRP and Shri Hemant Kumar, Safety Coordinator, TRP

Category B: R&D Labs and Industrial Units- Safety Award received by Shri P.V.Bhagwat, Head, Ion Accelerator Development Division, Shri S.K. Gupta, Head, FOTIA Section, IADD and Shri Arun Agarwal, Safety Coordinator, IADD

Category C: Engineering, Projects and Support Units- Safety Award received by Shri K.K.Singh, Project Director, INRPC, NRB, Tarapur, and Shri M. Domesa, Safety Coordinator, INRPC, Tarapur.

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

The CD of the Founder's Day Special Issue of the BARC Newsletter was released by Director, BARC on 29th October, 2015. This year, the Special issue carried 47 Award winning Papers; 34 papers on the DAE Excellence in Science, Engineering & Technology Awards for the year 2013 and 13 papers on Merit Awards received by BARC Scientists & Engineers in 2014. Out of the 34 DAE Award Papers, 4 papers were from Homi Bhabha Science & Technology Award winners, 10 from Scientific & Technical Excellence Award winners, 4 from Young Applied Scientist/Technologist Award winners, 3 from Young Engineer Award winners, 4 from Young Scientist Award winners and 9 from Group Achievement Award winners. The 13 Merit Awardees received Awards and Honours at various national and international seminars, symposia and conferences held in 2014. As with the regular issues of the BARC Newsletter, the Founder's Day Special Issue can be accessed through BTS and Lakshya portals and through the BARC website.

DAE (Excellence in Science, Engineering & Technology) Awards 2014

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 2014 were given on the eve of Founder's Day on October 29, 2015 in BARC. These were presented to the winners by the Chief Guest, Shri B. Bhattacharjee, Former Director, BARC and

The Awards were in the following categories:

A. Homi Bhabha Science & Technology Awards
B. Exceptional Service Awards
C. Scientific & Technical Excellence Awards
D. Young Applied Scientist / Technologist Awards
E. Young Scientist Awards
F. Young Engineer Awards
G. Special Contributions Awards
H. Meritorious Technical Service Awards
I. Group Achievement Awards
J. Meritorious Service Awards

Apart from the awards in the above categories, this year, two new Awards were instituted; Exceptional Service Award and Meritorious Technical Support Award.

A. 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, One from RRCAT and One from NFC. Following were the award winners from BARC:

1. Dr. Santosh Kumar Sandur, SO/G, RB&HSD, BSG, BARC.

Awarded for his innovative research contributions in Radiation biology leading to development of radio protective and chemo-therapeutic agents.

He has discovered several effective anti-inflammatory phytochemicals with reduced side effects. Two most important formulations developed by Dr. Santosh Kumar are based on chlorophyllin and a lectin. He has also discovered the immune-suppressive and anti-inflammatory molecules from medicinal plants and synthetic sources and tested them in preclinical experimental models.

Dr. Santosh Kumar Sandur receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

2. Dr. A.C. Bhasikuttan, SO/H, RPCD, CG, BARC

Awarded for his contributions in the field of "Supramolecular Photochemistry and Time resolved Spectroscopy". He has made significant contributions in the frontier areas of Chemical Sciences by establishing the construction/application of novel supramolecular and biomolecular assemblies potential as anticancer agents, targeted drug delivery, on-off sensors, nanocapsules and other molecular architectures. One of his notable findings has been on the demonstration of a fluorogenic molecule, which promptly induces and selectively detects G-quadruplex structures amidst other regular DNA forms.

Dr. A.C. Bhasikuttan receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

3. Shri Sanjay Malhotra, SO/H+, CnID, E&IG, BARC

Awarded for his contributions in the field of "Electromagnetic Design and Accelerator Technology". He made outstanding contributions in the field of Electromagnetic design and accelerator technology for various projects of DAE. Main contribution include Development of permanent magnets based focusing quadrupoles for the 20 MeV DTL for LEHIPA. Developed high field superconducting and normal conducting magnets for corrosion studies on structural steels for blanket module for ITER.

Shri Sanjay Malhotra, receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

4. Dr. D. Bhattacharyya, SO/G, A&MPD, PG, BARC

Awarded for his contributions in the field of "Synchrotron beamline development and utilization and Thin Film Multilayer devices". Has made significant contribution in development of the Energy Scanning EXAFS beamline at INDUS-2 Synchrotron source at RRCAT. Also contributed significantly towards fabrication of thin film multilayer structures for device applications. This development has significant commercial implications also.

Dr. D. Bhattacharyya receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

5. Shri Ayekpam Ibungohal, SO/F, PRPD, RPG, BARC

Awarded for his contributions in the field of "Indigenization and rectification of Electronic Control systems of compact LWRs". He has made outstanding contribution in indigenization of various electronic cards of Secondary Plant Control System with innovative designs addressing the problems of obsolescence, heat generation, compactness and reliability. He has solved EMI/EMC problems in NIS systems and addressed reliability issues in other Control Systems during commissioning and First Approach to Criticality of Project B.

Shri Ayekpam Ibungohal receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

6. Dr. Aruna Kumar Nayak, SO/H+, RED, RD&DG, BARC

Awarded for his contributions in the field of "Nuclear Reactor Thermal Hydraulics and Safety". He has designed several passive systems of AHWR from concept to detailed design and their verifications and validations so as to ensure that the reactor has sufficient margins for stable natural circulation during normal operational transients and adequate safety margins even under extreme events like Fukushima. Development of "APSRA" methodology & The AHWR core catcher design towards mitigating core melt down accidents. Recent invention is on the potential applications of nanofluids in water cooled reactors.

Dr. Aruna Kumar Nayak receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

7. Shri Vivek Bhasin, OS, RSD, RD&DG, BARC

Awarded for his outstanding contributions in the field of "Design and structural integrity, fitness-for-service assessment of components/structures of key reactor core and primary pressure boundary components of several Nuclear Power Plants in India and several nuclear facilities of BARC". Assessment of realistic safety margin, design modification, life assessment and assurance of continued safe operation for old/ operating NPPs. These activities have resulted in assurance of design qualification and requisite safety margins for new plants. He has developed several new in experimental & computational techniques and analysis procedures for accurate stress/strain assessment in house.

Shri Vivek Bhasin receiving the Homi Bhabha Science & Technology Award from Shri B. Bhattacharjee, Chief Guest and Former Director, BARC

B. Exceptional Service Award carries a Cash award of Rs 5 Lakhs, a Citation & a Medal.

Dr. Satish Chander Gupta, DS MRG, BARC, was the only recipient of this Award. Awarded for his excellent contributions in the field of "Research and Developments for Physics of Condensed Matter Under High Shock Compressions".

His contribution includes: Setting up of a comprehensive facility for shock wave research comprising various state-of-the-art techniques. Developed excellent theoretical capability for predicting the response of materials under high pressures. Built an extensive capability for computer simulation of the phenomenology of the underground nuclear explosions. Commissioned a neutron based hull monitoring system at reprocessing plant at NRB.

C. Scientific & Technical Excellence Award carries a Cash award of Rs 1 Lakh, a Citation and a Medal. There were Twenty Five award winners: Nineteen from BARC Two each from IGCAR and VECC, One each from RRCAT and BRIT. Following were the award winners from BARC:

1. Dr. K.R.S. Chandrakumar, SO/F TCS, CG, BARC
2. Dr. Ashok Kumar Verma , SO/F, HP&SRPD, PG, BARC
3. Shri Shyam Rao Ghodke, SO/F, APPD, BTDG, BARC
4. Dr. S.R. Shimjith, SO/G, RCnD, E&IG, BARC
5. Dr. Kondayya Gundra SO/F, ThPD, MRG, BARC
6. Shri Abhishant, SO/F, NRPSED, NRB, BARC
7. Shri V. Nataraju, SO/H, TPD, PG, BARC
8. Dr. Rahul Tripathi, SO/F, RCD, RC&IG, BARC
9. Dr. (Smt.) Susan Cherian, SO/G, ChD, CG, BARC
10. Dr. Srikumar Ghorui, SO/G, L&PTD, BTDG, BARC
11. Shri Sony Bordoloi, SO/G and Shri P.V. Sarngadharan, SO/G DRHR, DM&AG, BARC
12. Shri Kamal N. Karn, SO/H, CDM, DM&AG, BARC
13. Dr.(Smt.) Mary Alex, SO/F, ED, E&IG, BARC
14. Dr. (Smt.) Madhumita Goswami, SO/F, G&AMD, MG, BARC
15. Shri Radhe Shyam Prasad, SO/G, ED&DD, MRG, BARC
16. Shri Suneel Gattu, SO/E, KBNRP&C, NRB, BARC
17. Smt. Madhuri Anil Shetty, SO/F, FRD, NRG, BARC
18. Shri Prasanna Majumdar, SO/G, RSD, RD&DG, BARC
19. Shri Samiran Sengupta, SO/H, RRDPD, RG, BARC

D. Young Applied Scientist / Technologist Award carries a Cash award of Rs 50,000/-, a Citation and a Medal. There were Seven award winners: Five from BARC and Two from IGCAR. Following were the award winners from BARC:

1. Dr. Mohit Tyagi,SO/E, TPD,PG,BARC
2. Dr. Sujoy Biswas, SO/E, UED, ChEG, BARC
3. Smt. Kumud Singh, SO/E, CnID, E&IG, BARC
4. Shri Pritam Prakash Shete, SO/E, Computer, E&IG, BARC
5. Shri Ram Avtar Jat, SO/E, PDD, RC&IG, BARC

E. Young Scientist Award carries a Cash award of Rs 50,000/-, a Citation and a Medal. There were Eleven award winners: Nine from BARC, One from VECC and One from IGCAR. Following were the award winners from BARC

1. Dr. Rubel Chakravarty, SO/E, IP&AD, RC&IG, BARC
2. Dr. Mahesh Sundararajan, SO/D, TCS, CG, BARC
3. Dr. Srinivasu Kancharlapalli, SO/E, TCS, CG, BARC
4. Dr. Atindra Mohan Banerjee,SO/E, Chemistry, CG, BARC
5. Dr. Prakash C Rout,SO/E, NPD, PG, BARC
6. Dr. Soumyaditya Mula, SO/E, BOD, BSG, BARC
7. Dr. Vineet Kumar, SO/E, NPD, PG, BARC
8. Dr. Sandeep Kumar Sharma SO/E, RCD, RC&IG, BARC
9. Dr. Yogendra Singh Rajpurohit, SO/E, MBD, BSG, BARC

F. Young Engineer Award carries a Cash award of Rs 50,000/-, Citation and a Medal. There were eighteen award winners: Thirteen from BARC, Four from IGCAR and One from RRCAT. Following were the award winners from BARC:

1. Ms. Ramnik Singh,SO/D, CDM, DM&AG, BARC
2. Smt. Jilju Ratheesh V., TO/C, NXPF, PG, BARC
3. Shri Gangadhar Huddar SO/E, NRPSD&SA, NRB, BARC
4. Shri Rajib Das, SO/E, RPD, RPG, BARC
5. Shri Piush Purohit, SO/E, AFFF, Tarapur, NFG, BARC
6. Shri Sandeep Kumar Singh, SO/E, APPD, BTDG, BARC
7. Shri R. Vignesh, SO/D, PO&M(M), ChTG, BARC
8. Shri Gurpartap Singh, SO/E, DRHR, DM&AG, BARC
9. Shri Saurabh Kumar Neema, SO/E, ED, E&IG, BARC

10. Shri Harsh Hemani, SO/D, CAD, MRG, BARC
11. Shri Hrishikesh Chatterjee, SO/E, RTD, RD&DG, BARC
12. Smt. Argala Srivastava, SO/E, RPDD, RD&DG, BARC
13. Shri Ritesh K. Bagul, SO/E, RED, RD&DG, BARC

G. Special Contributions Award carries a cash award of upto Rs. 50,000/-, a Citation and a Medal. There were Eighty award winners. Seventy Eight were from BARC and Two from DAE. Following were the award winners from BARC:

1. Shri M.V.R. Srikanth, SO/F, KARP, NRB, BARC
2. Shri S. Ramasubramanian, SO/G, TRP, NRB, BARC
3. Shri Jaikaran, SO/F, TRP, NRB, BARC
4. Dr. C.B. Patil, SO/F, TRP, NRB, BARC
5. Shri Hemant Kumar, SO/E, TRP, NRB, BARC
6. Shri J. Udhayakumar, SO/F, IP&AD, RC&IG, BARC
7. Shri L.B. Pable, F/C, FCD, RC&IG, BARC
8. Dr. K.V. Lohithakshan, SO/F, FCD, RC&IG, BARC
9. Dr.J.V. Dehadrai, SO/G, FCD, RC&IG, BARC
10. Shri B.N. Kaul, SA/C, PDD, RC&IG, BARC
11. Smt. Yogita S. Gawde, SA/D, PDD, RC&IG, BARC
12. Shri A.B. Koli, Sr.T/H, PDD, RC&IG, BARC
13. Shri R.S. Kamble, WA/C, PDD, RC&IG, BARC
14. Shri R. L. Pasi, WA/B, PDD, RC&IG, BARC
15. Shri R.M. Ghodke,T/F, PDD, RC&IG, BARC
16. Shri P. Ginishkumar, SO/D, PDD, RC&IG, BARC
17. Shri S.P. Roy, SO/SB, PDD, RC&IG, BARC
18. Shri M.R. Chavan, Dr.Gr.I, NRB, BARC
19. Shri T.K. Saha, SO/G, L&PTD, BTDG, BARC
20. Shri V. Jha, SO/E, HPD, HS&EG, BARC
21. Shri P. Menon, SO/F, PRPD, RPG, BARC
22. Shri Switra Raj Vashishta, SO/G, PRPD, RPG, BARC
23. Shri Ankan Roy, SO/F, PRPD, RPG, BARC
24. Shri B. Srinivasan, SO/F, PRPD, RPG, BARC
25. Shri H.K. Saini, SO/F, PRPD, RPG, BARC
26. Shri R.E. Katkar, Dr.Gr.II, Director's Office, BARC
27. Shri G.M. Hebale, Sr.T/F, CDM, DM&AG, BARC
28. Shri R.N. Patil, Sr.T/H, CDM, DM&AG, BARC
29. Shri Rahul K. Chaudhary, SO/C, RP&AD, HS&EG, BARC
30. Shri Mahesh Tiwari, SO/D, EMAS, HS&EG, BARC
31. Shri Ajay Kumar Chikara, SA/D, RSSD, HS&EG, BARC
32. Shri Lalit Kumar Vajpyee, SA/D, RSSD, HS&EG, BARC
33. Shri P.R. Ninawe, SA/C, RSSD, HS&EG, BARC
34. Shri Govinda Mukherjee, SA/D, RSSD, HS&EG, BARC
35. Shri K.B. Shirsath, SA/D, RP&AD, HS&EG, BARC
36. Shri Nitin R. Kakade, SO/C, RP&AD, HS&EG, BARC
37. Shri Sridhar Sahoo, SO/E, RP&AD, HS&EG, BARC
38. Shri R.H. Chilkulwar, SO/D, RP&AD, HS&EG, BARC
39. Shri R.S. Vishwakarma, SO/D, RP&AD, HS&EG, BARC
40. Shri V.K. Thakur, SA/C, RP&AD, HS&EG, BARC
41. Shri M.J. Sonavane, SA/E, FRD, NRG, BARC
42. Shri Vikas, SA/D, RSSD, HS&EG, BARC
43. Shri Devi Prasad Mishra, SA/D, RSSD, HS&EG, BARC
44. Shri Anoj Kumar, TO/B, RSSD, HS&EG, BARC
45. Shri S.B. Deshpande, SA/D, RSSD, HS&EG, BARC
46. Shri Sunil K. Singh, SO/E, RP&AD, HS&EG, BARC
47. Shri Suman Lal, SO/D, TWMP, Strategic Group, BARC
48. Dr. Santosh H. Shinde, SO/C, RP&AD, HS&EG, BARC
49. Shri Sandip Mondal, SO/E, RP&AD, HS&EG, BARC
50. Shri K.K. Singh, SA/F, HPD, HS&EG, BARC
51. Shri H.D. Badgujar, SA/D, MFD, NFG, BARC
52. Shri R.N. Pujari, SA/F, RSSD, HS&EG, BARC
53. Shri Anil Ravindra Khot, SO/C, HPD, HS&EG, BARC
54. Shri Prasad Sajin, SO/C, RSSD, HS&EG, BARC
55. Shri M.K. Kamble, SA/D, IHSS, HS&EG, BARC
56. Shri A.R. Mhatre, SA/E, FRD, NRG, BARC
57. Shri Anil M. Gupta, SA/D, HPD, HS&EG, BARC
58. Shri P. Krishnakumar, SA/E, RSSD, HS&EG, BARC
59. Shri S.A. Yadav, SO/D, RSSD, HS&EG, BARC
60. Shri Jagdish K. Divkar, SO/C, RSSD, HS&EG, BARC
61. Shri V.J. Pawar, SA/E, RSSD, HS&EG, BARC
62. Shri S.L. Patil, SA/D, RSSD, HS&EG, BARC
63. Shri M.P. Jayan, SA/E, RSSD, HS&EG, BARC
64. Shri Dinesh K. Patre, SA/E, RSSD, HS&EG, BARC
65. Shri P.S. Sorte, SA/D, RSSD, HS&EG, BARC

66. Shri R.R. Bhingare, SO/D, RP&AD, HS&EG, BARC
67. Shri Mridulendu Pandey, SO/C, HPD, HS&EG, BARC
68. Shri Praveen Dubey, SO/C, IHSS, HS&EG, BARC
69. Shri S.S. Deolekar, SO/C, BSCS, Strategic Group, BARC
70. Shri J.D. Sharma, SO/E, IHSS, HS&EG, BARC
71. Shri M.T. Valvi, SA/D, RSSD, HS&EG, BARC
72. Shri M.V.R. Narsaiah, SO/C, RSSD, HS&SG, BARC
73. Shri D.G. Mishra, SA/E, HPD, HS&EG, BARC
74. Shri Kamlesh, SA/E, HPD, HS&EG, BARC
75. Shri M.T. Saify, SO/F, AFD, NFG, BARC
76. Shri D.B. Sathe, SO/G, AFFF, Tarapur, NFG, BARC
77. Shri A.J. Mane, F/B, AFD, NFG, BARC
78. Shri R.K. Singh, F/C, MFD, NFG, BARC

H. Meritorious Technical Service Award carries a Cash award of Rs 20,000/-, Citation and a Medal. There were Twenty Eight award winners; Eighteen from BARC, Four each IGCAR and RRCAT and One each from Kalpakkam and VECC.

1. Shri K.S. Munankar, Sr.T/J, RB&HSD, BMG, BARC
2. Shri P.S. Adhikari, SA/E, N&XPF PG, BARC
3. Shri Ajaj Husain, SA/E, TSD, ESG, BARC
4. Shri Suryakant N. Mahajan, Sr.T/H, RSSD, HS&EG, BARC
5. Shri P.A. Bhaskaran, F/C, PRPD, RPG, BARC
6. Shri A.J. Almeida, Sr.T/J, L&PTD, BTDG, BARC
7. Shri Mohan Singh Dhapola, Sr.T/H, CDM, DM&AG, BARC
8. Shri Manohar Lal, T/G, CED, ESG, BARC
9. Shri S.P. Mhatre, F/C, MPD, MG, BARC
10. Shri B.S. Nair, F/D, PMD, MG, BARC
11. Shri U.R. Ram, Sr.T/H, Cryo-Tech.Div. , MRG, BARC
12. Shri G.S. Nagrale, SA/E, TRP, NRB, BARC
13. Shri Clement Ambrose, F/B, TRP, NRB, BARC
14. Shri K. Venkatasubramanian, F/C, FRD, NRG, BARC
15. Shri S.B. Sharma, T/H, MD&PDD, PG, BARC
16. Shri R.R. Dahivalkar, Sr.T/H, RRMD, RG, BARC
17. Shri K.S. More, Sr.T/J, AFFF/Tarapur, NFG, BARC
18. Shri M. Sivadasan, F/B, Conversion Facility, RMP/ BARC

I. 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 Forty Two Groups received these awards. Out of these, Twenty Five (plus one jointly with IGCAR) were from BARC, Five from IGCAR, Four from RRCAT, Two each from HWB and VECC and One each from NFC, DAE Secretariat, AMD and BRIT.

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

1. Smt. Shailaja Prakasam, DEO, Admn. Group, BARC
2. Shri K. Srinivas, Head, CED, ESG, BARC & Shri R.K. Mishra, SO/F, FRD, NRG, BARC.
3. Dr. S.J. Jambhulkar, SO/G, & Dr. P. K. Mukherjee, SO/G, NA&BTD, BSG, BARC
4. Shri R.P. Hans, SO/H, BSCS, BSC, BARC
5. Dr. B.N. Jagatap, DS & Director, Chem. Gr., BARC.
6. Shri S.K. Gupta, SO/F, UED, ChEG, BARC.
7. Shri A. Shriniwas Rao, Head, MDS, ChTD/ChTG, BARC.
8. Shri K.C. Guha, OS & Project Manager (PO&M), ChTG, BARC, Mysuru.
9. Shri A.K. Sinha, OS, Head, CDM, DM&AG & Shri K.K. Abdulla, OS & Ex-Head, AFD, NFG, BARC.
10. Shri R.C. Sharma, Director, RG,BARC & Shri K.N. Vyas, A.D., RPG, BARC.
11. Shri A.K. Sinha, OS, Head, CDM, DM&AG, BARC.
12. Dr. Raj Mangal Tripathi, SO/H+, Head, HPD/ HS&EG, BARC & Dr. R.B. Oza, SO/G, RSSD,HS&EG BARC
13. Shri P. Chaudhury, SO/G, Head, RMS&MS, RSSD, HS&EG, BARC & Dr (Kum) Pramilla Damodar Sawant, SO/G, RSSD, HS&EG, BARC.
14. Dr. J. K. Chakravartty, OS, Director, MG, BARC.
15. Dr. Satish C. Gupta, Assoc. Director, MRG, BARC.
16. Shri P. Nagaraju, SO/H+, Head, HLU&ESS, NFG, BARC.
17. Shri Sunil Gulati, SO/F, Suptd (Op), TRP, NRB, BARC/Tarapur.

18. Shri I. Vishwaraj, Plant Supdt., TWMP, TNRPO, NRB, BARC.
19. Shri R. S. Soni, Former Head, TDD, NRG, BARC & Shri N. J. Shukla, Foreman/C, FRD, NRG, BARC.
20. Dr. Amar Sinha, OS & Head, NXPD, PG, BARC.
21. Dr. N.K. Sahoo, OS, & Head, A&MPD, PG, BARC.
22. Dr. Ashutosh Dash, Head, IP&AD, BARC. & Dr. Sharmila Banerjee, Head, RPhCS, RC&IG, BARC.
23. Shri R. J. Patel, DS & Head, RTD, RD&DG, BARC & Shri S. Raghupathy, SO/H+, Head, CH&MD/RDG, IGCAR.
24. Shri B.S.V.G. Sharma, OS, Head TT&CD, BARC & Dr. A.K. Nayak, Head, ThHS, RED, RD&DG, BARC
25. Dr. M.G.R. Rajan (OS) & Head, RMC, BARC.
26. Shri K.V. Ravi, OS, Head, PRPD, RPG, BARC Facilities

J. Meritorious Service Award carries a cash prize of Rs. 20,000/-, a citation and a medal. There were Thirty one Award winners. Twenty five were from BARC, Two from IGCAR and each from DAE, RRCAT, VECC and AMD. Following were the award winners from BARC:

1. Shri Kishorilal Rana, Dr.Gr.I, RC&IG, BARC
2. Smt. N. Lakshmi, AAO, AD,Adm., BARC
3. Shri K.A.R. Bhounsle, Dr.SG, RMP/BARC
4. Smt. M.S. Pushpa, Sr.PS, RMP/BARC
5. Shri Suresh A. Karande, Dr.Gr.I, BARC
6. Shri Punaram D. Thapa, T/B, PD, Adm., BARC
7. Shri P.D. Shringi, Sr. AO, Accounts, Adm., BARC
8. Shri Ashok P. Lad, S.Guard, PD, Adm., BARC
9. Shri Malkit Chand S. Bhanwal, Dr.Gr.I, PD, Adm., BARC
10. Shri A. Unnikrishnan, Sr.PS., E&IG, BARC
11. Shri Rupendra S. Palwankar, Asstt., Medical, BARC
12. Smt. Rajni M. Mirchandani, Sr.Clerk, LWRD, RPG, BARC
13. Shri A.G. Sudheendra, APO, RMP/BARC
14. Shri R.L. Mungekar, Asstt.,PD,Adm.,BARC
15. Smt. Ragini R. Patange, UDC, PD, Adm., BARC
16. Shri T. Vallinayagam, Dr. SG, Traffic/PD, Adm., BARC
17. Shri Bhaurao D. Yewale, Traffic/PD, Adm., BARC
18. Shri Sunil K. Telkar, Asstt., PD, Adm., BARC
19. Smt. Anita Ramachandran, Asstt., PD, Adm., BARC
20. Shri Mahadev D. Rane, Sec.Guard, PD, Adm., BARC
21. Shri I. Murugesan, Security Guard, PD, Adm., BARC
22. Shri Natarajan Srinivasan, Sr.PS, Controller's Office, Adm., BARC
23. Smt. Ankita Sunil Utekar, Steno Gr.II., P&CD, BARC
24. Shri Kartar Singh Rana, T/F, PD, Adm., BARC
25. Sh Dnyandeo N. Datir T/F, PD, Adm., BARC

Analytical approaches in optimization of design of Electrical system of INRP Project at Tarapur

H. Mishra
Engineering Services Group

Sekhar Basu
Deparment of Atomic Energy

and

C.V. Raman and M. Kushwah
Integrated Nuclear Recycle Plant Reprocessing Design,
Nuclear Reclycle Board

Abstract

Integrated Nuclear Recycle Plant (INRP) will be the first integrated nuclear fuel recycle facility where spent fuel storage, reprocessing, waste management plants & waste storage will be integrated into a single entity by locating all the civil structures in a single campus. Electrical power system of the plant comprises of various normal, emergency & un-interruptible power supplies in line with the existing nuclear recycle plants & the safety guide lines for such radio chemical facility. The power supply systems are significantly large and spread over length & breadth of the plant area. A large number of transformers and associated switch gear & cabling systems are envisaged for development of the power system network. In order to arrive at an optimum design solution, a number of technically feasible options for 6.6 kV and 415V power distribution network were analysed and compared techno economically.

This paper covers the analytical approaches adopted in design of such electrical systems of INRP Project at Tarapur. It involves Load Flow Study and Short Circuit Analysis using ETAP software as well as manual calculation of Steady State and Transient Voltage Dip. Load-flow study was performed to determine the steady-state operation of an electric power system. The voltage drop on each feeder, the voltage level at each bus, and the power flow in all branches and feeder circuits were calculated. It was determined if system voltages remain within specified limits under various contingency conditions, and whether equipment such as transformers and cables are protected against overload. Load-flow study was used to identify the need for additional active Power, capacitive, or inductive VAR support, or the placement of capacitors and/or reactors to maintain system voltages within specified limits. Prospective losses in each branch and total system power losses were also calculated. The short circuit study models the current that flows in the power system under abnormal conditions of all types of three phase short circuit faults and determines the prospective fault current in an electrical power system at various buses. The short circuit study was performed for both the typical and worst case scenarios.

RAMI analysis will be carried out for power distribution system for checking reliability, availability, maintainability and inspectability aspects of the system. The RAMI approach consists of four main steps: (1) performing function analysis; (2) analyzing initial failure modes, effects and criticality; (3) initiating risk mitigation actions to ensure compatibility with RAMI objectives; (4) integrating as RAMI requirements.

Keywords

ETAP, Load Flow, Short Circuit Analysis, Steady State, Transient Voltage, RAMI Analysis.

Introduction

INRP will be the first integrated nuclear fuel recycle facility where spent fuel storage, reprocessing, waste management plants & waste storage will be integrated into a single entity by locating all the civil structures in a single campus with suitable connectivity between them.

Several common blocks like Utility blocks, Block 106, Block 103, Exhaust Air Blocks (108A/B/C/D), Supply fan blocks, Electrical block (132), DG blocks (119 A/B) & Block 115, stores, Main Control Room (Block 101) etc. will cater to the needs of both reprocessing as well as waste management process & storage systems. O & M (Operation & Maintenance) personnel and administrative machinery will also serve to both the above mentioned systems.

The plant is designed to process spent fuel received from PHWRs (Pressurized Heavy Water Reactors) with an objective to recover Plutonium (Pu) and Uranium (U) meeting the required product specifications. The plant's design capacity is 600 tonnes of Heavy Metal (HM) per annum. The plant is under construction on a plot near to TAPS 3 & 4, Tarapur, having width of 658 m at one side & 454 m at other side and length of 558 m for this project.

The plant is functionally divided into various blocks. Electrical system for project INRP comprises of Class IV, Class III, Class II and Class I power supply systems for the various utility and process loads of the facility. Class IV and Class III power supplies for various blocks are provided from Electrical Block (132) and DG Blocks (119A/B).

Class IV Mains power supply for INRP project, Tarapur will be received through two (2) independent 33 kV underground feeders from nearby source i.e. 33 kV indoor substation to be located within TAPS 1 and 2 Switchyard, to Electrical Block. Mains Power at 33 kV level will be stepped down to 6.6 kV level in Electrical block by installing 2 nos. 20/ 25 MVA outdoor oil-cooled transformers. Power at 6.6 kV level will be distributed to MV load centres i.e. Compressed air Plant, Chiller Plant etc. and also to DG block (119A), as well as to other load distribution centres viz., Substations at Supply Fan Block 1 (107A) & 2 (107B) etc. 6.6 kV feeders in DG block are proposed to be multiplied & extended to other two load distribution centres viz. Exhaust Air Block-4 (108D) & UOF Block (122). 6.6/0.433 KV, 2.5 MVA indoor dry type transformers are planned in blocks 132, 107A, 107B, 119A, 108D & 122 for catering to the entire class-IV load requirements of various blocks of INRP. Localised Class-II and Class-I power supply systems are proposed to be located in each of the blocks 132, 121A/B, 101, 102A/B, 105, 106, 110, 111, 113, 114, 119A, 122, 147.

Simultaneous maximum demands for class IV, class III, class II distribution systems are as follows:

Class IV Maximum demand: 16 MVA.
Class III Maximum demand: 5 MVA.
Class II Maximum demand: 500 kVA.

The power supply systems are significantly large and spread over length & breadth of the plant area. A large number of transformers and associated switch gear & cabling systems are envisaged for development of the power system network. In order to arrive at an optimum design solution, a number of technically feasible options for 6.6 kV and 415V power distribution network were analysed and compared techno economically.

Short circuit analysis, Load flow study and transient voltage analysis have been carried out. RAMI analysis is in progress.

Objectives

These studies have been carried out to find out the best location and optimum capacity for the transformers, switchgears & cable feeders, to ensure:

- High reliability, safety, availability and maintainability of power supply.
- Steady state and transient voltage drops within limits as per Indian Electricity Rules.
- Optimum rating and capacity utilization of equipments viz. transformers, switchgears, cables etc.

- Minimal distribution losses.
- Reduced cable & cable tray lengths and cable sizes resulting in substantial savings & ease of cable laying.
- Optimum capital and running cost.

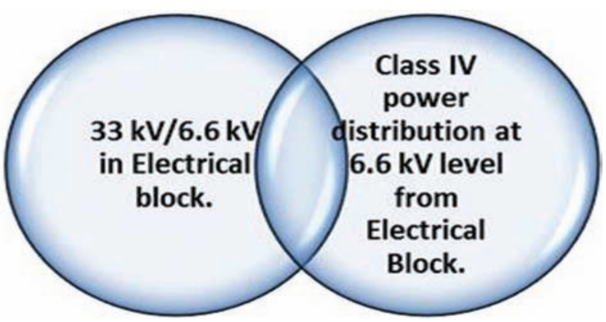
Power distribution network options analyzed:

To achieve the above objectives and to arrive at the optimum solution, a number of technically feasible options for 6.6 kV and 415V power distribution have been compared technically. Following comparative studies were carried out for:

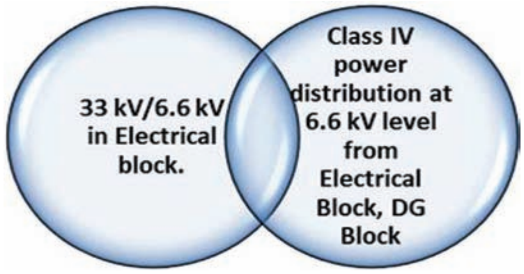
- Two technically feasible options for 6.6 kV distribution.
- Eight technically feasible options for 415V distribution.
  - Comparison of Steady state voltage drops.
  - Comparison of Transient voltage dips.
  - Comparison of ohmic losses.
  - Comparison of cable sizes.
  - Cost analysis for Cables & cable trays.

The schemes for 6.6 kV and 415V power distribution were selected after comparison of the above parameters and arriving at an optimum solution, as detailed below.

Case I: Comparisons of the two options for 6.6 kV power distribution:



Option-1



Option-2

Cable and cable tray lengths were more in Option 1 of 6.6 kV Power Distribution Scheme. Also, laying of cables over service rack would have become very cumbersome.

Difference in cost estimates for Option 1 and Option 2 (for 6.6 kV power distribution) = 2.01Cr

Considering the above, it was found that Option 2 is better for 6.6 kV Power distribution from technical as well as commercial point of view.

Case II: Comparison of the eight options for 415V power distribution:

16 nos. of 6.6 kV/433V, 2.5 MVA transformers located at three load centres viz. Electrical block, DG block, UOF block in **Option 1.**

16 nos. of 6.6 kV/433V, 2.5 MVA transformers located at five load centres viz. Electrical block, DG block, Admin block, Training Centre block, UOF block in **Option 2.**

18 nos. of 6.6 kV/433V, 2.5 MVA transformers located at four load centres viz. Electrical block, DG block, SA fan-1 block, SA fan-2 block in **Option 3.**

16 nos. of 6.6 kV/433V, 2.5 MVA transformers located at four load centres viz. Electrical block, DG block, Admin block, UOF block in **Option 4.**

18 nos. of 6.6 kV/433V, 2.5 MVA transformers located at four load centres viz. Electrical block, DG block, Training Centre, UOF block in **Option 5.**

18 nos. of 6.6 kV/433V, 2.5 MVA transformers located at three load centres viz. Electrical block, DG block, UOF block in **Option 6.**

Fig. 1: Photograph of Electrical Block (132)

18 nos. of 6.6 kV/433V, 2.5 MVA transformers located at three load centres viz. Electrical block, DG block, SA fan-2 block in **Option 7.**

16 nos. of 6.6 kV/433V, 2.5 MVA transformers located at six load centres viz. Electrical block, DG block, SA fan-1 block, SA fan-2 block, Block 122, EA fan-4 block in Option 8. (DG Block is having 6 nos. transformers, out of which 4nos. are dedicated for Class-III System). The layout of selected **option 8** of LV distribution scheme is shown as annexure 1. The photograph of newly constructed Electrical Block is shown in Fig. 1

Load Flow Study

Load flow studies are one of the most important aspects of power system planning and operation. The load flow gives us the sinusoidal steady state of the entire system viz. voltages, real and reactive power generated and absorbed and line losses. Since the load is a static quantity and it is the power that flows through transmission lines, the purists prefer to call this Power Flow studies rather than load flow studies. We shall however stick to the original nomenclature of load flow.

Through the load flow studies, we can obtain the voltage magnitudes and angles at each bus in the steady state. This is rather important as the magnitudes of the bus voltages are required to be held within a specified limit. Once the bus voltage magnitudes and their angles are computed using the load flow, the real and reactive power flow through each line can be computed. Also based on the difference between power flow in the sending and receiving ends, the losses in a particular line can also be computed. Furthermore, from the line flow, we can also determine the over and under load conditions.

The steady state power and reactive power supplied by a bus in a power network are expressed in terms of nonlinear algebraic equations. We have therefore adopted iterative methods for solving these equations.

Methods:

Newton–Raphson solution method: This method begins with initial guesses of all unknown variables (voltage magnitude and angles at load buses and voltage angles at generator buses). Next, a Taylor Series is written, with the higher order terms ignored, for each of the power balance equations included in the system of equations. The result is a linear system of equations that can be expressed as:

$$\begin{bmatrix} \Delta\theta \\ \Delta|V| \end{bmatrix} = -J^{-1}\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}$$

where ΔP and ΔQ are called the mismatch equations:

$$\Delta P_i = -P_i + \sum_{k=1}^{N} |V_i|\,|V_k|\,(G_{ik}\cos\theta_{ik} + B_{ik}\sin\theta_{ik})$$

$$\Delta Q_i = -Q_i + \sum_{k=1}^{N} |V_i|\,|V_k|\,(G_{ik}\sin\theta_{ik} - B_{ik}\cos\theta_{ik})$$

and J is a matrix of partial derivatives known as a Jacobian:

$$J = \begin{bmatrix} \frac{\partial \Delta P}{\partial \theta} & \frac{\partial \Delta P}{\partial |V|} \\ \frac{\partial \Delta Q}{\partial \theta} & \frac{\partial \Delta Q}{\partial |V|} \end{bmatrix}$$

The linearized system of equations is solved to determine the next guess (m + 1) of voltage magnitude and angles based on:

$$\theta^{m+1} = \theta^{m} + \Delta\theta$$

$$|V|^{m+1} = |V|^{m} + \Delta|V|$$

The process continues until a stopping condition is met. A common stopping condition is to terminate if the norm of the mismatch equations is below a specified tolerance.

A rough outline of solution of the power-flow problem is to:-

1. Make an initial guess of all unknown voltage magnitudes and angles. It is common to use a "flat start" in which all voltage angles are set to zero and all voltage magnitudes are set to 1.0 p.u.
2. Solve the power balance equations using the most recent voltage angle and magnitude values.
3. Linearize the system around the most recent voltage angle and magnitude values.
4. Solve for the change in voltage angle and magnitude.
5. Update the voltage magnitude and angles.
6. Check the stopping conditions, if met then terminate, else go to step 2.

Other Methods:

Gauss–Seidel method: This is the earliest devised method. It shows slower rates of convergence compared to other iterative methods, but it uses very little memory and does not need to solve a matrix system.

Fast-decoupled load-flow method: This method is a variation on Newton-Raphson that exploits the approximate decoupling of active and reactive flows in well-behaved power networks, and additionally fixes the value of the Jacobian during the iteration in order to avoid costly matrix decompositions. It is also referred to as "fixed-slope, decoupled NR". Within the algorithm, the Jacobian matrix gets inverted only once, and there are three assumptions. Firstly, the conductance between the buses is zero. Secondly, the magnitude of the bus voltage is one per unit. Thirdly, the sine of phases between buses is zero. Fast decoupled load flow can return the answer within seconds whereas the Newton Raphson method takes much longer. This is useful for real-time management of power grids.

Holomorphic embedding load flow method: A recently developed method based on advanced techniques of complex analysis. It is direct and guarantees the calculation of the correct (operative) branch, out of the multiple solutions present in the power flow equations.

Load flow study for INRP:

Load flow study has been carried out for planning operation of Class-IV power systems of Integrated Nuclear Recycle Plant (INRP) at Tarapur. Master One Line Diagram of INRP is attached as Annexure-2.

Technical comparison of 415V power distribution schemes is shown below. Transient voltage dip calculation for option 8 is also attached as annexure-3. The study is performed for the worst case scenario when the highest rating motor at 415V bus is started. Steady state voltage drops for various load centres for selected option 8 of LV distribution is shown as Fig. 2.

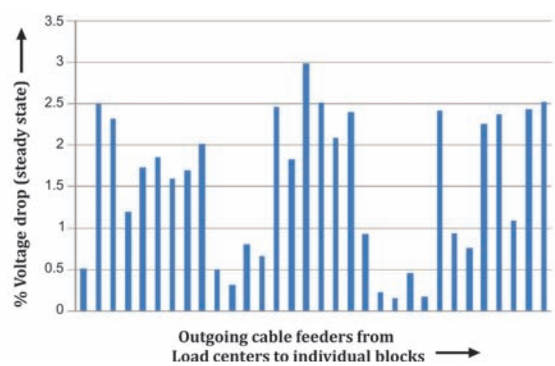


Fig. 2: Voltage drops during Steady state condition (Option 8)

Technical comparison of 415V power distribution schemes:

Sl. No	Item	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
1.	Voltage drop	9.6% max.	6% max.	5.3% max.	8.1% max.	7.9% max.	9.4% max.	8.1% max	2.99% max
2.	Ohmic losses	840 kW	350 kW	260 kW	570 kW	540 kW	720 kW	500kW	200kW
3.	Cable length	109 km	47 km	39 km	75 km	71.5 km	94 km	65km	23km
4.	Cable tray length	27 km	19 km	15.6 km	26 km	21.5 km	23.8 km	20.3km	9km
5.	Ease of laying of cables over service rack	Cumber some	Easy	Easier	Cumber some	Cumber some	Cumber some	Easy	Easiest
6.	Remarks	Cable density & no. of eqpts very high leading to conges-tion	Cable density & no. of eqpts low.	Cable density & no. of eqpts low.	Cable density & no. of eqpts very high leading to conges-tion	Cable density & no. of eqpts very high leading to conges-tion	Cable density & no. of eqpts very high leading to conges-tion	Cable density & no. of eqpts low.	Cable density & no. of eqpts low.

Considering the above, it is found that **Option 8** is better for 415V Power distribution from technical as well as commercial point of view.

Short Circuit Analysis

A balanced 3-phase fault implies that all three phases of the power system are simultaneously short-circuited to each other through a direct or "bolted" connection. The other types of unbalanced short-circuit faults are important in selecting the time-current characteristics and settings of phase-overcurrent and ground-fault protective devices to provide selective coordination. This coordination assures service continuity and minimizes damage to switchgear and load equipment. However, unbalanced fault calculations are more difficult to perform for industrial and commercial power systems and require knowledge of the method of symmetrical components.

Electrical Transient Analyser Program (ETAP)

ETAP is the most comprehensive solution for the design, simulation, and analysis of generation, transmission, distribution, and industrial power systems. ETAP organizes the work on a project basis. Each project that we create provides all the necessary tools and support for modelling and analysing an electrical power system. A project consists of an electrical system that requires a unique set of electrical components and interconnections. In ETAP, each project provides a set of users, user access controls, and a separate database in which its elements and connectivity data are stored.

Short Circuit Analysis on ETAP

In order to determine the currents resulting from an asymmetrical fault, the values of per unit (p.u.) zero, positive and negative sequence impedances of transformers, generators, cables etc. are required.

Calculation Methods

Initial Symmetrical Short Circuit Current Calculation

Initial symmetrical short-circuit current (I_k'') is calculated using the following formula:

$$I_k'' = \frac{cU_n}{\sqrt{3}Z_k}$$

where Z_k is the equivalent impedance at the fault location, c is the voltage factor and U_n is the nominal system voltage. Voltage factor c is the ratio of equivalent voltage to nominal voltage and is used to adjust the value of the equivalent voltage source for minimum and maximum current calculations.

Peak Short Circuit Current Calculation

Peak short-circuit current (i_p) is calculated using the following formula:

$$i_p = \sqrt{2}\, k I_k''$$

where k is a function of the system R/X ratio at the fault location.

Symmetrical Short Circuit Breaking Current Calculation

For a far-from-generator fault, the symmetrical short circuit breaking current (I_b) is equal to the initial symmetrical short circuit current.

$$I_b = I_k''$$

For a near-to-generator fault, I_b is obtained by combining contributions from each individual machine. I_b for different types of machines is calculated using the following formula:

$$I_b = \begin{cases} \mu I_k'' & \text{for synchronous machines} \\ \mu q I_k'' & \text{for asynchronous machines} \end{cases}$$

where μ and q are factors that account for AC decay. They are functions of the minimum time delay and the ratio of the machine initial short circuit current to its rated current, as well as real power per pair of poles of asynchronous machines.

IEC Standards allow you to include or exclude AC decay effect from asynchronous machines in the calculation.

Steady-State Short circuit current Calculation

Steady-state short circuit current I_k is a combination of contributions from synchronous generators and power grid. I_k for each synchronous generator is calculated using the following formula:

$$I_{k\max} = \lambda_{\max} I_{rG}$$
$$I_{k\max} = \lambda_{\min} I_{rG}$$

where λ is a function of a generator excitation voltage, ratio between its initial symmetrical short circuit current and rated current, other generator parameters, and I_{rG} is the generator rated current.

The steady-state short circuit current calculated is dependent on the option selected for Short circuit current in the study case. If the Max and User-Defined c Factor is selected, the maximum steady-state short circuit current is reported. If the Min option is selected, the minimum steady-state short circuit current is reported.

This maximum steady-state short circuit current is used to determine minimum device ratings. The minimum steady-state short circuit value is used for relay coordination purposes in preventing the occurrence of nuisance trips and loading deviations.

Inputs

- Main One Line Diagram.
- Fault level at 33 kV bus is considered as 1500 MVA and the 33 kV bus has been considered in swing mode.

Basis/Methodology

- The Power System has been Modelled Using ETAP PowerStation Software, ver. 11.0.0.
- ETAP program calculations are in compliance with latest edition of IEC standards.
- Nodes are generated by ETAP software while connecting two impedances, e.g. between transformer impedance and cable impedance.
- The nomenclatures of the buses have been decided based on the block to which they are feeding.

Short Circuit Analysis for INRP

Short circuit analysis has been carried out to confirm that, during symmetrical and asymmetrical fault, the fault current should not exceed the anticipated maximum fault level. Short circuit analysis has been carried out at 33kV, 6.6kV and 415V buses. All these buses are connected by utility 33 kV connections through transformers to the switchgear. The short circuit level at faulted buses are found, which help in selecting the circuit breaker. ETAP Short Circuit Case study results are attached as Annexure-4.

Conclusion

The selected options for MV and LV distribution (Option 2 for MV distribution and option 8 for LV distribution) have resulted in significant reduction of cabling with cable racks (86 km reduction in cabling), substantial savings of about 20 Crores on account of cabling & cable racks (on comparison with option 1 for MV and LV distribution), and also in energy conservation. Further on account of reduction in cable power losses, energy savings of the order of Rs. 5 Crores is achieved per year. All transformer installations in blocks 107A/B, 108D and 122 will be unmanned and monitored remotely through Electrical SCADA and CCTV. SCADA and CCTV controls are proposed to be provided in blocks 132 and 119A, which will be manned substations. View stations are also provided in Main control room and Utility control room.

Short circuit analysis has been carried out at 33kV, 6.6kV and 415V buses. The short circuit level at faulted buses are found, which help in selecting the circuit breaker. Fault at 415V Class III EPCC-A1 bus has highest fault level with DG breaker closed and tie line breaker closed. L-L-G fault has the highest contribution level in all of the cases considered in comparison to all other asymmetrical faults. It is ensured that short circuit fault current duties are in compliance with the latest editions of the ANSI/IEEE Standards (C37 series) and IEC Standards (IEC 60909 and others). RAMI analysis will be carried out for power distribution system for checking reliability, availability, maintainability and inspectability aspects of the system.

Acknowledgment

The authors sincerely thank Shri S. Basu, Director, BARC & Chairman NRB for his continuous support and encouragement in all the activities pertaining to the design of electrical systems for nuclear fuel recycle facilities. The authors thank Shri Shashank Srivastava for his help in carrying out short circuit analysis using ETAP. The authors also thank Ms. Ambika Raja, SA/E, INRPRD and Shri Jai Prakash, TO/C, INRPRD for their help in writing the paper. The authors also thank their colleagues of INRPRD for providing all necessary help in extending whole hearted co-operation in design of the systems and in writing this paper.

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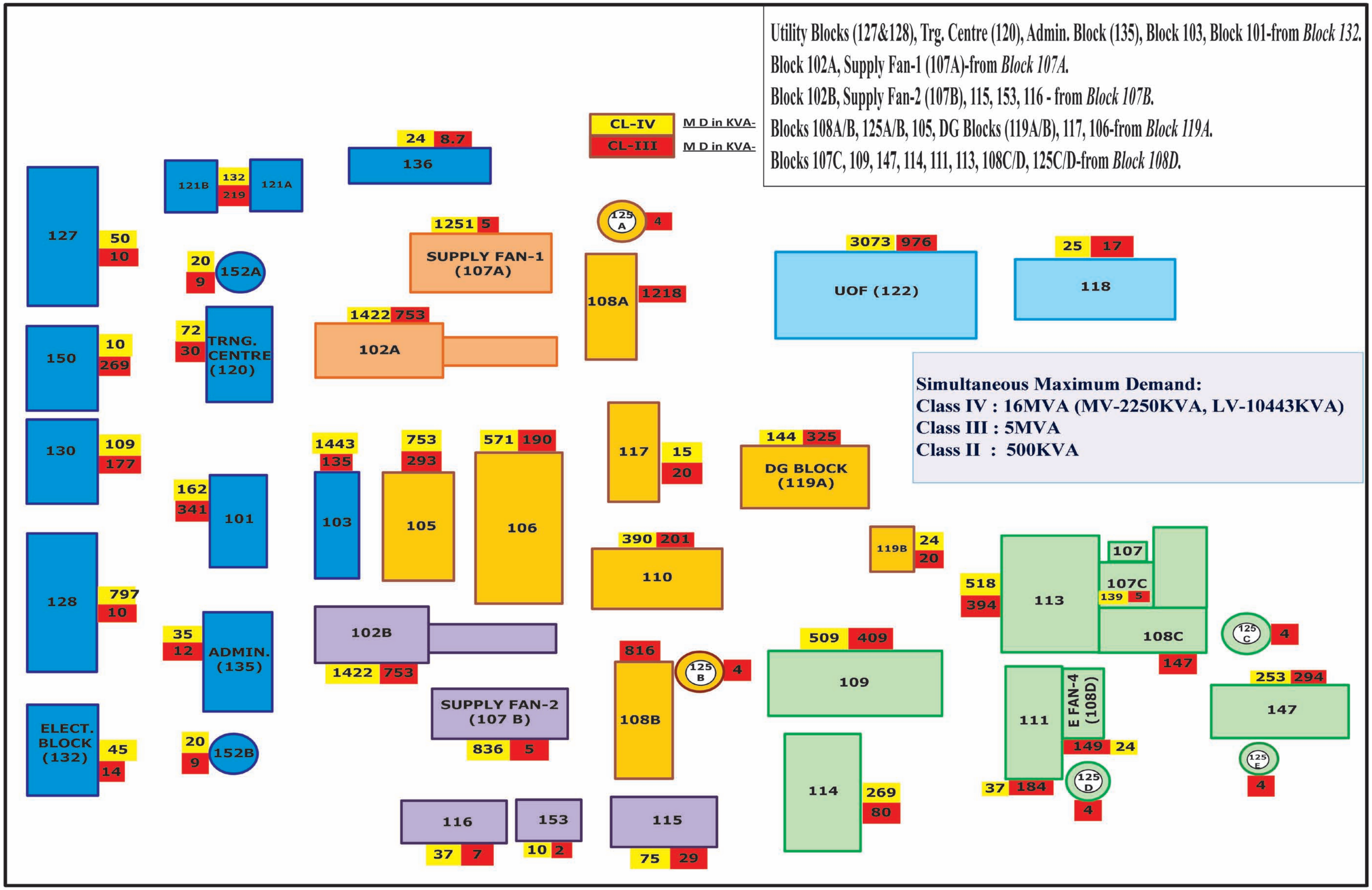
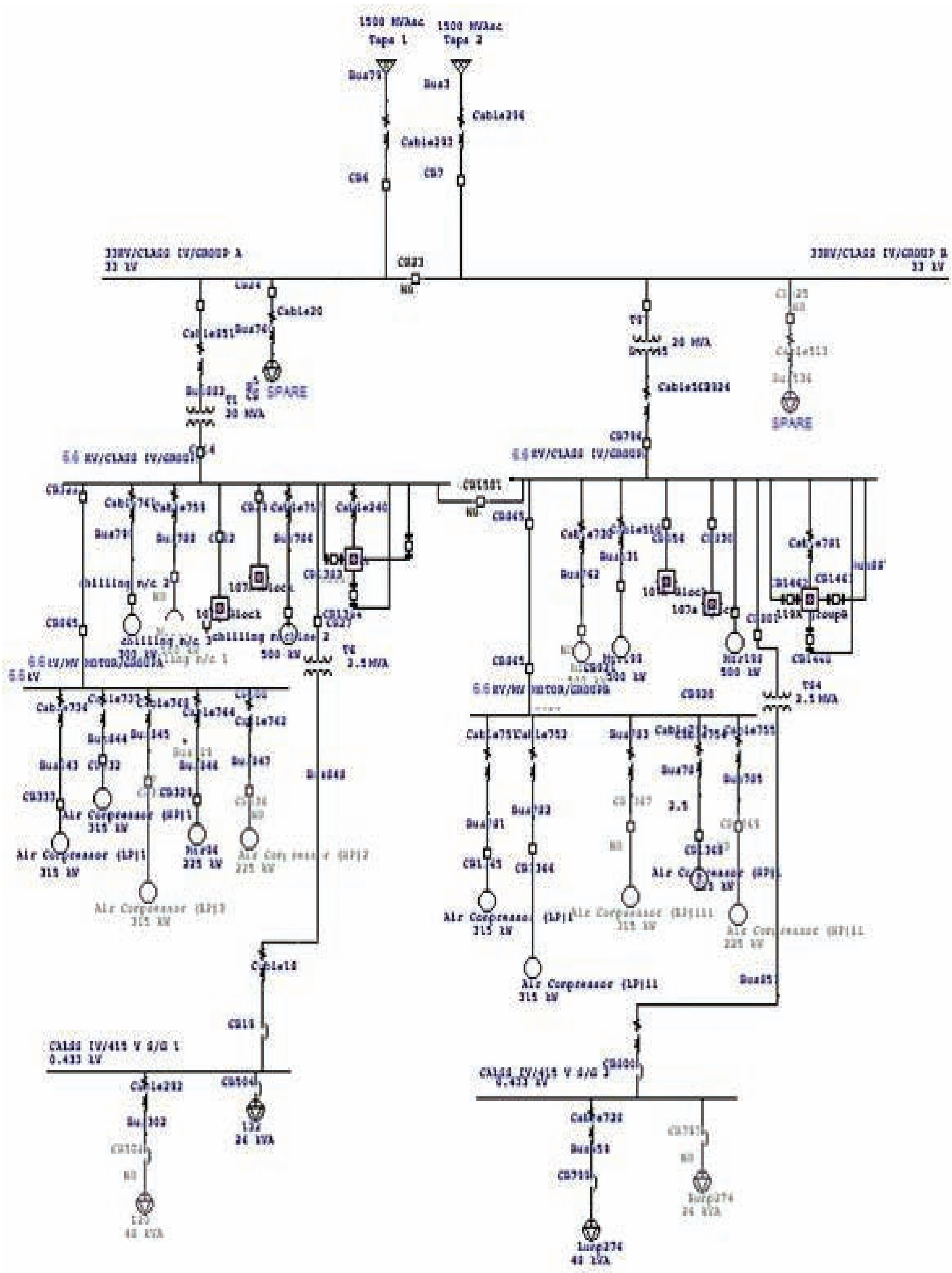
5. Literature on Short Circuit using ETAP, available on webpage www.etap.com.

Annexure-1: Selected Distribution Scheme (Option-8)





Annexure-2 : Master One Line Diagram of INRP

Annexure-3: Transient Voltage Drop Calculation for Option 8 of LV distribution

For NPCC-A in Supply air fan Block-107A:

1. Input Data

1.1 Rated voltage = 415V
Fault MVA = 31.35MVA (Fault MVA at 415V level is calculated by considering a fault level of 1500MVA at 33 kV level at the source end i.e. TAPS 1&2 Switchyard).

1.2 Rating of highest motor (i.e. Supply air fan) connected to NPMCC in Supply Air Fan Room-1(107-A) = 110 kW
Motor Full load current = 189A

1.3 Total running load on NPCC-A with highest motor running = 2.117 MVA

1.4 Total running load on NPCC -A without highest motor = 1.9795 MVA.

1.5 Cable from NPCC-A in Supply Air Fan (107-A) to proposed NMCC-A in Supply Air Fan Room-1(107-A)
Size = 3C x 400 sq. mm 1.1 kV Al XLPE cable.
Length of cable = 9 mtr.
No. of runs = 6
Resistance of Cable = 0.100 ohm/km (at 90°C)
Reactance of Cable = 0.0704 ohm/km
Impedance of Cable = 0.12229 ohm/km
Total impedance of cable = 0.000183 ohm

1.6 Cable from proposed NMCC-A to Supply air fan motor
Size of cable = 1x3x 120sq. mm. 1.1kV Al XLPE cable.
Length of cable = 45mtr.
No. of runs = 1
Resistance of cable = 0.324 ohm/km (at 90°C)
Reactance of cable = 0.0712 ohm/km
Impedance of cable = 0.3317 ohm/km
Total impedance of cable = 0.01493 ohm

1.7 For bus duct from Transformer to NPCC in Supply Air Fan (107-A)
Length of bus duct = 7mtr.
Resistance = 0.01171 ohm/km (at 95°C)
Reactance = 0.00549 ohm/km
Impedance = 0.01293 ohm/km
Total Impedance of Bus duct = 0.00009051 ohm

2. Assumption

2.1 Base MVA = 100
2.2 Base kV = 0.415
2.3 Starting current of motor = 2.5 Ifl (considering VFD starting of motor)
2.4 Starting p.f. of motor = 0.2 lag
2.5 Outgoing cable impedance is neglected for all the feeders except S.A Fan.
2.6 Allowable voltage dip during starting of motor = 15% at motor terminals.
2.7 Voltage across motor terminals is assumed as 1 p.u. before starting.

3. Calculation of impedances at base MVA

Source

$$Z\,(\text{source}) = \frac{\text{Base MVA}}{\text{Fault MVA}} = \frac{100}{31.35} = 3.19\ \text{p.u.}$$

Cable

Incoming cable

$$Z\,(\text{cable1}) = \frac{Z\,(\text{actual}) \times \text{Base MVA}}{(\text{Base kV}) \times (\text{Base kV})} = \frac{0.000183 \times 100}{0.415 \times 0.415} = 0.106\ \text{p.u.}$$

Outgoing cable to SA fan

$$Z\,(\text{cable2}) = \frac{Z\,(\text{actual}) \times \text{Base MVA}}{(\text{Base kV}) \times (\text{Base kV})} = \frac{0.01493 \times 100}{0.415 \times 0.415} = 8.669\ \text{p.u.}$$

Bus Duct

$$Z\,(\text{Bus Duct}) = \frac{Z\,(\text{actual}) \times \text{Base MVA}}{(\text{Base kV}) \times (\text{Base kV})} = \frac{0.00009051 \times 100}{(0.415) \times (0.415)} = 0.0526\ \text{p.u.}$$

Base Load

$$Z\,(\text{base load}) = \frac{\text{Base MVA}}{\text{MVA (base load)}} = \frac{100}{1.9795} = 50.52\ \text{p.u.}$$

Motor

$$\text{Motor Starting MVA} = \sqrt{3} \times I_{st} \times 0.415 = \sqrt{3} \times 2.5 \times 189 \times 0.415/1000 = 0.3396$$

$$Z\,(\text{motor}) = \frac{100}{0.3396} = 294.46\ \text{p.u.}$$

Calculation of Voltage Dip

3.2.1 Equivalent circuit before motor starting is as indicated in Fig. 3

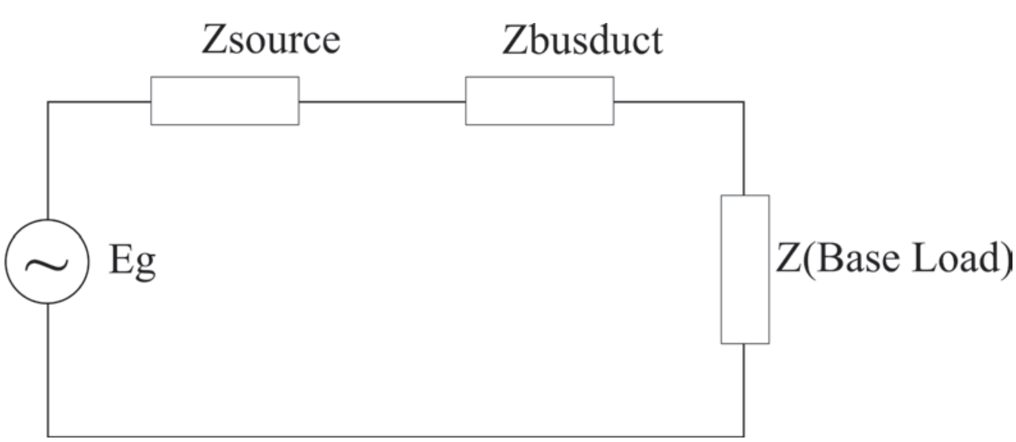


Fig. 3

The voltage at motor terminal before starting of motor is assumed as 1 p.u.

Equivalent impedance of circuit $= Z\,(\text{source}) + Z\,(\text{busduct}) + Z\,(\text{base load})$

$= 3.19+0.0526+50.52 \quad = 53.7626$

Current I_1 flowing in network $= \dfrac{E_g}{\text{Equivalent impedance}} = \dfrac{E_g}{53.7626} = 0.018600\, E_g$

Voltage across motor terminals before starting $= I_1 \times Z\,(\text{base load})$

$1 \text{ p.u.} = 0.018600\, E_g \times 50.52$

$1 \text{ p.u.} = 0.93967 E_g$

$E_g = 1.064 \text{ p.u.}$

Equivalent circuit during motor starting is as indicated in Fig. 4

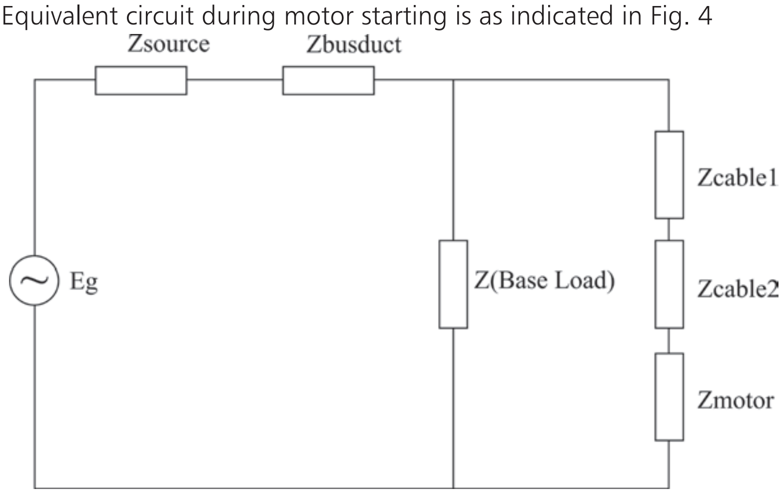


Fig. 4

Equivalent impedance $= [Z\,(\text{source}) + Z\,(\text{busduct}) + (Z\,(\text{base load}) \,||\, (Z\,(\text{cable1}) + Z\,(\text{cable2}) + Z(\text{motor}))]$

$= 3.19 + 0.0526 + (50.52 \,||\, (0.106 + 8.669 + 294.46)) = 46.55 \text{ pu}$

Total current drawn from supply $= \dfrac{E_g}{\text{Equivalent impedance}} = \dfrac{1.064}{46.55} = 0.0229 \text{ pu}$

Current through motor branch $= \dfrac{\text{Total current from supply} \times Z\,(\text{base load})}{Z\,(\text{cable1}) + Z\,(\text{cable2}) + Z\,(\text{motor}) + Z\,(\text{base load})}$

$= \dfrac{0.0229 \times 50.52}{0.106 + 8.669 + 294.46 + 50.52} = 0.00327 \text{ p.u.}$

Voltage across motor during starting in p.u. $=$ Current through motor branch x Z (motor)

$= 0.00327 \times 294.46 = 0.9629 \text{ p.u.}$

Voltage dip $= \dfrac{1 - 0.9629}{1} \times 100 = 3.7\,\%$

The transient voltage dip is within limits (15%).

Annexure 4 : ETAP Study Cases 1 to 4

I. Study Case 1:

Fault at Group A 33kV bus with tie breaker open.

Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

Bus		3-Phase Fault			Line-to-Ground Fault				Line-to-Line Fault				*Line-to-Line-to-Ground			
ID	kV	I_k''	i_p	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k
132/33KV/CLASS IV/Group A	33.000	21.714	50.043	20.535	18.887	43.528	18.887	18.887	18.787	43.298	18.787	18.787	20.611	47.502	20.611	20.611

All fault currents are in rms kA. Current i_p is calculated using Method C. (from ETAP software)

* LLG fault current is the larger of the two faulted line currents.

Where, I_k'' - Initial symmetrical current (kA, rms)
I_p – Peak Current (kA)
I_b – Breaking current (kA, rms, symm)
I_k – Steady state current (kA, rms)

II. Study Case 2:

Fault at 6.6 kV bus of Group A with tie breaker open.

Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

Bus		3-Phase Fault			Line-to-Ground Fault				Line-to-Line Fault				*Line-to-Line-to-Ground			
ID	kV	I_k''	i_p	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k
132/6.6KV/CLASS IV/Group A	6.600	29.672	72.508	22.359	28.790	70.353	28.790	28.790	25.554	62.444	25.554	25.554	29.814	72.855	29.814	29.814

All fault currents are in rms kA. Current I_p is calculated using Method C. (from ETAP software)

* LLG fault current is the larger of the two faulted line currents.

III. <u>Study Case 3:</u>

Fault at 415V EPCC-A1 bus with DG breaker closed and tie line CB closed.

Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

Bus		3-Phase Fault			Line-to-Ground Fault				Line-to-Line Fault				*Line-to-Line-to-Ground			
ID	kV	I_k''	i_p	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k
119A/CLASS III/415V EPCCA1	0.433	62.609	139.196	12.904	56.507	125.631	56.507	56.507	54.126	120.337	54.126	54.126	61.783	137.360	61.783	61.783

All fault currents are in rms kA. Current I_p is calculated using Method C. (from ETAP software)

* LLG fault current is the larger of the two faulted line currents.

IV. Study Case 4:

Fault at 415V EPCC-A1 bus with DG breaker closed and tie line CB open.

Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

Bus		3-Phase Fault			Line-to-Ground Fault				Line-to-Line Fault				*Line-to-Line-to-Ground			
ID	kV	I_k''	i_p	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k	I_k''	i_p	I_b	I_k
119A/CLASS III/415V EPCCA1	0.433	25.682	58.962	5.785	24.960	57.304	24.960	24.960	22.241	51.062	22.241	22.241	25.580	58.727	25.580	25.580

All fault currents are in rms kA. Current I_p is calculated using Method C. (from ETAP software)

* LLG fault current is the larger of the two faulted line currents.

Wilson Disease DNA Microarray and Diagnosis

Manjula Mathur and A.V.S.S.N. Rao
Molecular Biology Division

Abstract

Customized DNA microarrays were developed for detection of sequence variations causing Wilson disease. Our WDDMs (Wilson Disease DNA Microarrays) were found to have >80% accuracy in detection. This is a proof-of-principle demonstration of the utility of low-density microarrays for genetic diagnosis.

Metabolic disorders - WILSON DISEASE (WD) as an example

Micronutrients are very important component of our diet and are required in small quantities by most organisms for optimal physiological function. These include vitamins and minerals such as iron, copper, iodine, zinc etc. Excess or deficiency of these can cause impaired cell functions and eventually cell death. Their levels in our body are tightly regulated by critical enzyme systems[1,2] whose imbalance could be due to a defect in one or more genes. We are born with about 21000 genes and the total gene coding regions constitute about 2% of our total genetic content (genome). When a disorder is linked to a single inherited gene, it is referred to as an inherited monogenic disease. It may be noted that, as of now more than 5000 inherited monogenic disorders are known in humans and their frequency of occurrence varies across populations and geographical locations.

Copper is a transition metal element, which has a natural property of getting easily converted between two redox states namely oxidized Cu (II) and reduced Cu (I). Because of this unique property, biological systems have made Cu metal to get manifested as an important catalytic co-factor for a variety of metabolic reactions in them[3]. Copper, like vitamins, is required in tiny amounts for us to remain healthy and we get it from many foods. Dietary copper is absorbed in the stomach and duodenum where it mainly binds to circulating albumin, and is taken up by various tissues. The daily requirement for copper is approximately 0.75 mg. Excess copper is predominantly excreted into the bile, where it ends up as fecal copper. Renal losses account for only 5 to 15 percent of the daily excretion.

Wilson disease was first described in 1912 by a British neurologist Dr. Samuel Alexander Kinnier Wilson (1878-1937) as a clinical condition of hepatolenticular degeneration caused by defect in cellular copper transport. In Wilson's disease copper accumulates, over a period of time, in the liver (hepato cellular) and other tissues including the brain (lenticular nucleus), causing damage to the organs and resulting in the hepatic, neurologic and psychiatric manifestations of the disease. Above certain levels of intracellular copper accumulation, it could even enter the nucleus and damage DNA causing unpredictable damage to cellular functions and, total chaos to the system. Thus, WD is fatal unless detected early and treated before serious illness from copper poisoning develops. More than 30 million people worldwide are estimated to be affected by the disease.

Disease causing mutations in a gene occur in less than 1% cases in the population while some of the variations remain silent and not affect the function of the gene(s). Wilson's disease is a metabolic disorder rooted to a gene named ATP7B, located on chromosome number 13. The ATP7B gene is encoded by 22 exons spread over 80kb of genomic region. This gene was cloned, sequenced and characterized in 1993. WD occurs at a frequency of 1 in 30,000 whereas its carrier frequency is estimated to be 1:90[4]. Nearly 600 different disease causing mutations in ATP7B have been reported and are compiled as Wilson disease mutation database[5].

Disease Diagnosis - Detection by DNA microarray

Data pertaining to the nature of mutations and their locations is the starting point to design DNA sequence based diagnostic methods. DNA microarray is the method of choice when a large number of disease causing mutations have to be detected simultaneously in an unknown sample. In an effort to augment the clinical diagnosis of WD, we have taken up the indigenous development of Wilson Disease DNA Microarray (WDDM) by detecting the presence of pathological mutations in ATP7B in suspected WD patients and their kin.

We analysed the population distribution of WD causing mutations from existing literature and short listed those prevalent in Indian population for the development of WDDM. Some of these mutations that affect the functional domains of the WD protein were found among Indians as well as other populations. Short DNA sequences (oligo probes) spanning the above regions were chemically synthesized in pairs (normal and mutated, i.e., control and test probes). For uniform micro-spotting of DNA probe solutions, on epoxy coated glass slides an indigenous PC controlled micro-arrayer was used[6]. Nearly seventy probe pairs covering 63 WD mutations were printed under ultra clean atmosphere with controlled humidity. The spotted slides were examined under microscope before conducting hybridization experiments.

Samples were derived from the ATP7B gene region of the individuals by PCR amplification, Digoxigenin (DIG) labeled, and were hybridized to WDDMs (forming DNA hetro-duplexes). The hybridization signals were detected with the help of anti-DIG antibody and the scanned hybridized slides were quantified by the use of image analysis methods[7]. Laboratory generated mutated samples were hybridized on WDDMs to assess the specificity of the WDDMs. The scanned image of a typical WDDM after hybridization with a mutated sample is shown in Fig. 1C. All these six mutations could be detected with >95% confidence. On the same lines, sensitivity of our detection method[7] was evaluated after quantitative analysis of spot intensities from multiple hybridization experiments and was found to be >80% .

Conclusion

DNA hybridization based methodology for diagnosis of Wilson Disease was established using a microarray based approach. In our study nearly 80% of probes showed required spot intensity differentiability. This study demonstrated that designed WDDMs and the protocols followed can be used for disease diagnosis as a cost-effective first-pass screening tool. Dr. Arnab Gupta an expert on WD mutations and associated patho-physiology at Johns Hopkins University, MD (USA) considers our approach of developing low-density microarrays as a major step not only for diagnosis of WD but also for monogenic disorders

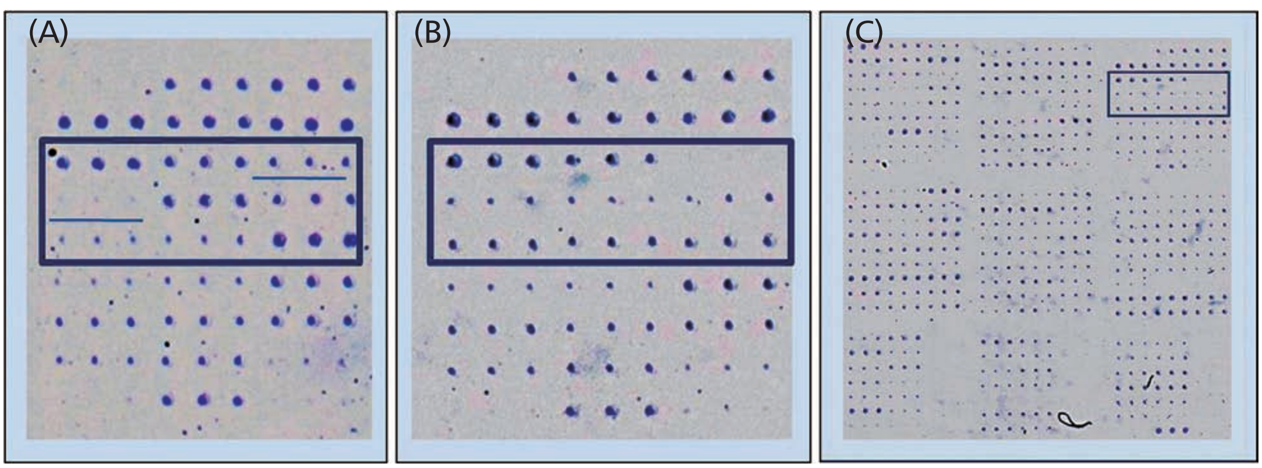


Fig. 1: Hybridized WDDM: Fig1A and Fig1B show magnified view of grid 3 of microarray slide hybridized to normal (A) and mutant (B) samples. Fig1C is an image of the complete microarray – the boxed part has probe pairs (in triplicate) pertaining to specific mutation (underlined in Fig1A).

as a whole[8]. In India, this is perhaps the first attempt in the direction of developing a diagnostic DNA-microarray for detection of genetic disorders. A similar approach can be used for the diagnosis of other monogenic diseases including haemoglobinopathies viz. thallassemia, sickle cell disease, inherited cancers etc.

Present Perspective

In this era of 'genomics', determining the DNA sequences of complete genomes has become a reality due to technological advancements. This has lead to a better understanding of the genetic contributions to human health and fueled the emergence of newer areas of research such as pharmacogenomics, metabolomics and personalized medicine. The microarray-based genomic technologies and integration of microelectronics[9] have the potential to exploit the genetic information for developing affordable tools for genetic diagnosis.

Acknowledgements

We heartily thank Dr. Rita Mukhopadhyaya, In-Charge, DNA Sequencing Facility, MBD, for her support and help with editing of the manuscript.

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Development of Induction Skull Melting Technology

G. Sugilal, Shashi Kumar, M.H. Rao, S.K. Mishra, J. Jha and K. Banerjee
Nuclear Recycle Group
and
G.K. Dey
Materials Group

Abstract

BARC had developed and indigenized cold crucible induction melter technology for high temperature glass melting applications. In order to extend this technology for metal melting applications, development of Induction Skull Melting was undertaken. As a part of the indigenous development of the ISM technology, a systematic numerical simulation was carried out initially to arrive at the design parameters of the segmented crucible. Based on the model-based design, an induction skull melting facility comprising of a water-cooled segmented copper crucible with in-situ casting module, induction heating power supply system, cooling water recirculation systems, vacuum chamber with vacuum delivery system and associated instrumentation & control units was built. The ISM facility was successfully tested for melting and homogenizing different metals and alloys. The ISM technology is the most preferred technology when highly refractory and extremely reactive metals and their alloys are to be processed with ultra high purity.

Introduction

Induction Skull Melting (ISM) is an advanced technology used for melting highly reactive metals such as titanium, zirconium etc. In ISM, a water-cooled, copper crucible is used to melt the metallic charge. The crucible has a segmented cylindrical wall so that the magnetic field can penetrate into the metallic charge to be melted. As the metal melts inside the segmented crucible, it solidifies against the floor of the crucible, forming a thin skin or 'skull' on the surface. Melting of reactive metals such as zirconium and titanium and their alloys are carried out under vacuum or inert atmosphere. Therefore, the segmented crucible is housed inside a vacuum chamber.

The induction skull melting is very energy intensive process on account of the water cooling of the segmented crucible. Depending on the thermal conductivity of the skull, it insulates the molten metal from the cooling effect of the crucible. Moreover, the Lorentz forces caused by the electromagnetic field partially levitate the melt and thereby, reduce heat exchange between the liquid metal and the skull. This results in a considerable amount of superheat required for practical applications and the stirring effect created by the induction coil results in a uniform temperature distribution throughout the melt. By virtue of the strong electromagnetic stirring, the ISM technology is also useful for producing alloys from their constituent metals having great differences in their densities and melting points.

Model-based Design

Number of segments of the crucible, its shape and spacing between them strongly influence the performance of the CCIM. The heat generation due to eddy currents induced in the segmented crucible is governed by these factors. The electrical efficiency decreases with increase in the number of segments because lesser power is released in the charge and more power is wastefully released in the fingers. However, the arcing risk between the segments reduces as the number of segments increases. Therefore, the first step towards this development was a systematic study to understand the effect of various design parameters and selection of appropriate values of these parameters to meet the design objectives (see Fig. 1 and Table 1). Numerical simulations were carried out to assess the impact of air gap between the segmented crucible and primary inductor. Similarly, the effect of coil pitch was investigated by increasing the pitch from 5 mm to 10 mm. The corresponding induced heats are tabulated in Table 2.

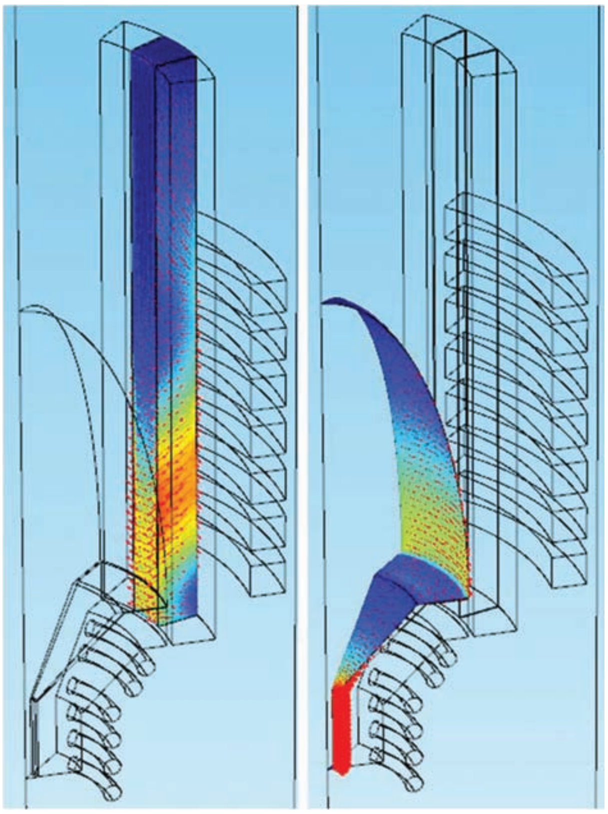


Fig. 1: Power induced in different parts of the segmented crucible (simulation results)

Table 1: Power induced in different faces of one finger (simulation results)

Finger Face	Induction heat (kW)	Induction heat (%)
Front	1.3	22.5
Back	1	17.5
Sides	3.4	59.4
Top	0.006	00.1
Bottom	0.03	00.5

Induction Skull Melting Facility

Based on the model-based design, the induction skull melting system comprising of a water-cooled segmented copper crucible, induction heating power supply system, cooling water recirculation systems, was procured from M/s. GH Induction India Pvt. Ltd., Chennai. The vacuum chamber and vacuum delivery system were procured from M/s. Hind High Vacuum Company Pvt. Ltd., Bangalore. Installation and integration of all subsystems including various cooling water circuits were completed in the Engineering Hall of the CDCFT Building in WIP Complex and tested successfully (see Fig. 2).

Segmented Crucible

The new segmented crucible has 12 water-cooled fingers, which are arranged to form a cylindrical cavity with 120 mm diameter and 250 mm height. The copper crucible is provided with a water-cooled adjustable bottom to facilitate in-situ casting of the melt. The crucible is made of electrolytic tough pitch copper. The segmented crucible as well as the adjustable bottom are properly cooled by circulating cooling water at adequate pressure such that these components are maintained at sufficiently low temperature during the melting and casting operations. Fig. 3 shows the water-cooled segmented crucible complete with the inductor and in-situ casting module.

Induction Coil and Power Supply

The induction coil has 5 turns with an inside diameter of 170 mm and coil height 200 mm. The induction

Table 2: Power (kW) induced in different components of the induction skull melter (Primary current = 5750 A (rms), Frequency = 15 kHz)

Case studies	Melt	Crucible	Chamber
(i) 5 mm air gap & 5 mm pitch	129.8	118.7	9.7
(ii) 10 mm air gap & 5 mm pitch	124.9	107.1	11.4
(iii) 5 mm air gap & 10 mm pitch	131.3	124.6	7.8

Fig. 2: Induction skull melting facility in BARC

coil is energised with one number of 600 kW, 15 kHz, full bridge, IGBT-based induction heating primary power supply comprising of rectifier, inverter, and heat station with tank capacitor. The induction coil inside the vacuum chamber is connected to the output of heat station through vacuum compatible co-axial power feed-through with Bayonet coupling to feed the power to the segmented crucible.

Vacuum Delivery System

The vacuum delivery system consists of a vacuum chamber meant for housing the segmented crucible, induction coil and a set of vacuum pumps. The vacuum chamber have an inside diameter of 900 mm and a height of 1200 mm. It has a double-wall construction to facilitate water cooling of the chamber. The ceiling of the chamber is provided with a copper heat sink (cooling shroud) to avoid excessive heating by the thermal radiations from the molten mass. The required vacuum is created by a set of rotary pump, roots pump, diffusion pump and holding pump. The ultimate vacuum produced by the vacuum delivery

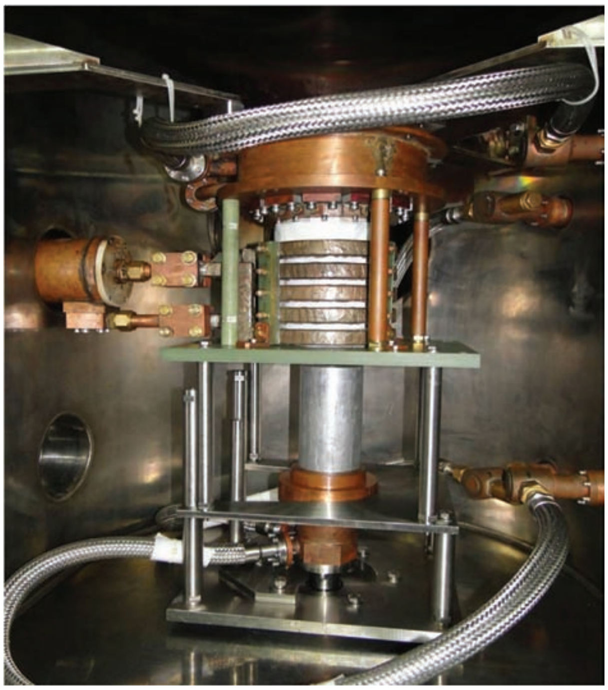


Fig. 3: Water-cooled segmented crucible complete with inductor and in-situ casting module

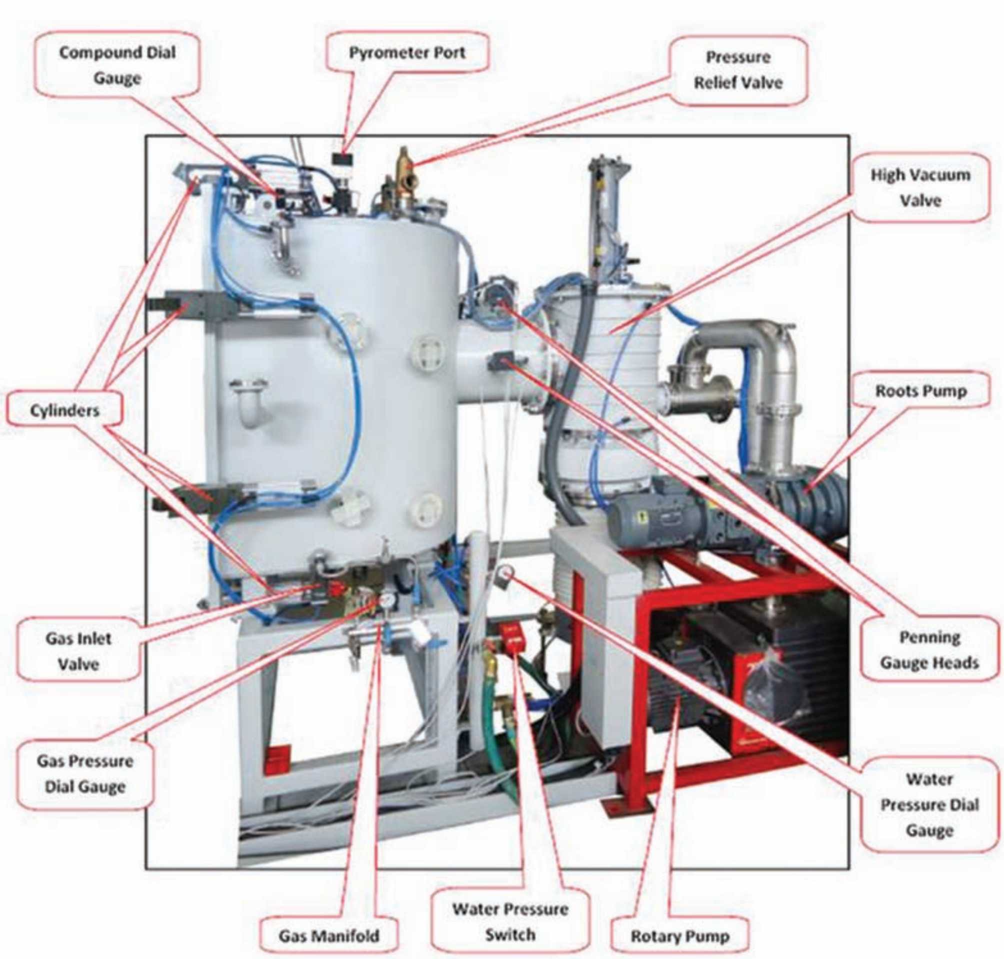


Fig. 4: Components of the vacuum delivery system

system is 10^{-5} mbar and the working vacuum is 10^{-4} mbar. The vacuum delivery system is provided with adequate instrumentation and controls. Vacuum level in the chamber is measured on-line using Pirani and Penning gauges. Multiple levels of pressure relief valves are provided to avoid any pressure build up in the chamber. Components of the vacuum delivery system is shown in Fig. 4.

Primary Cooling Water System

The primary cooling water recirculation system consists of three independent cooling water (DM Water) circuits to cool the induction heating power supply and the segmented cold crucible, respectively. Each loop has a DW water storage tank, a vertical multi-stage stainless steel pump, a plate type heat exchanger and associated instrumentation and controls (see Fig. 5). The instrumentation include DM water level in the tank, pressure at the pump discharge, flow rate in the DM water header and inlet-outlet temperature measurements which are available for process control.

Secondary Cooling Water System

The secondary cooling water recirculation system consists of three independent cooling water circuits (one for induction heating power supply and another two for segmented cold crucible) to cool the primary cooling water. The heat load of the secondary cooling water is removed in an induced draft cooling tower with an installed capacity of 1000 kW.

Emergency Cooling Water System

An emergency cooling water system is provided to cool the induction skull melter and induction heating power supplies when the normal cooling mode fails.

Fig. 5: Cooling Water System for Melter and Generators

An overhead tank with a capacity of 1000 L DM water is provided to ensure the melter cooling for about 30 minutes.

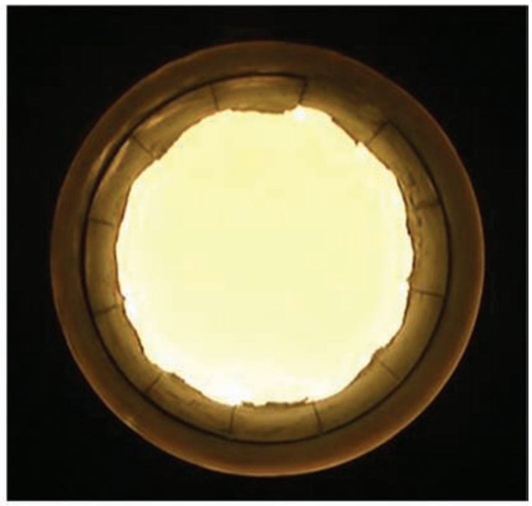
Melting Experiments

Melting trials were carried out using during the commissioning phase of the ISM Facility. 4.1 kg (~ 1.5 L) of aluminum, in the form of cut-pieces of 1 inch diameter rod, was charged initially. Subsequent de-gassing was carried out under vacuum and melting was carried out under high purity Argon (99.99%) environment. The induction heating power was increased from 50 kW to 300 kW in steps of 50 kW. The molten aluminum was casted in-situ and the casted ingot was withdrawn from the crucible using hydraulic power-pack. The longitudinal cut section of ingot showed excellent homogeneity. Subsequently stainless steel melting trials were carried out to establish high temperature melting. 11.9 kg (~1.5 L) of stainless steel, in the form of cut-pieces of 1 inch diameter rod, was charged into the segmented crucible. Like in the previous case, de-gassing was carried out under vacuum and melting was carried out under high purity Argon (99.99%) environment. The induction heating power was increased from 50 kW to 400 kW in steps of 50 kW. The in-situ casting was carried out with and without heating power control. The ingot obtained with controlled cooling had a better surface appearance. Fig. 6 shows different stages of melting and casting of stainless steel. The ingot was cut to generate vertical and horizontal sections and inspected visually to check the extent of melting and skull formation.

Summary

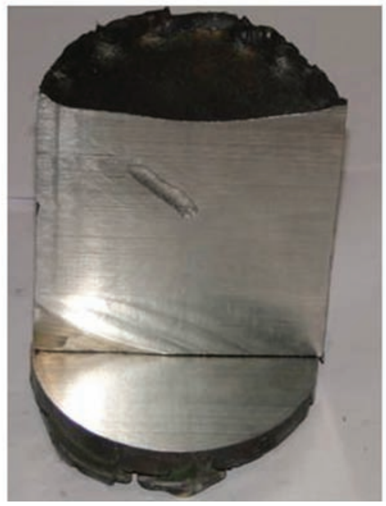
Induction skull melting is globally emerging as an advanced technology for electromagnetic processing

Stainless steel charge before melting



Melting of stainless steel completed

Stainless steel ingot after in-situ casting



Vertical and horizontal cut sections

Fig. 6: Different stages of stainless steel melting and casting

of materials ranging from highly reactive metals to high temperature superconducting oxide materials. The ISM technology offers several advantages such as high temperature availability, long melter life, high purity, etc. In view of various important applications in frontier areas of material research, BARC has developed induction skull melting technology in house. By virtue of the strong electromagnetic stirring, the ISM technology can also be used to homogenize alloys of metals which are difficult to be combined uniformly in composition due to great difference in specific gravity. Further induction skull melting experiments are being taken up to establish these aspects quantitatively.

Acknowledgements

The authors are grateful to Dr. S. Basu, Director, Bhabha Atomic Research Centre for his constant support towards the development of ISM technology. The author is also thankful to Dr. J.K. Chakravarthy and Dr. N. Krishnamurthy for extending invaluable support to this programme. The support and encouragement extended by Shri K.N.S. Nair, Shri S.D. Misra, Shri V.D. Sutar, Shri S.K. Jha, Shri R.K. Sadhu, Dr. J.G. Shah, Shri P.I. Hadagali and Shri V.R. Chari are also gratefully acknowledged. Technical contributions of Shri T. H. Gowri Shankar, Shri Neeraj Kumar, Shri S. Satheesh Kumar, Shri D.D. Pawar, Shri V.G. Karande, Shri V.W. Kasbe, Shri B.R. Meena and Shri K.A. Naik are appreciatively acknowledged.

Design & Development of Facility for Production of Active Cs-137 Source Pencils for Blood Irradiator

Satish B. Patil, Jyoti Jha, Puneet Srivastava, Shakti Mishra, Rituparna Datta and Siddhartha S. Khan

Technology Development Division

Abstract:

The search for an option for a radioactive source, alternative to Co-60, is on for quite some time. Abundance of Cs-137, a high yield radionuclide, in the nuclear waste has prompted the idea of separation of the same from the nuclear waste and making it suitable for medical and industrial applications. This will give the societal benefits in addition to revenue generation. Longer half life of Cs-137 (30 Yrs) is an added advantage of using this isotope over Co-60. Hence, as a special emphasis in Indian Nuclear Waste Management programme, a facility has been designed, installed and commissioned for production of Cs-137 source pencils in vitrified form to be used as source pencils for blood irradiation.

Introduction

In India Co-60 is the isotope presently being used for medical applications. It needs frequent replacement because of its short half life (5.27 Years) resulting in multiple handling, transportation and loading-unloading operations. Further, in Indian scenario, production of Co-60 also leads to reactivity losses and in turn revenue losses to the nuclear power reactors. However, Cs-137, the major constituent of the nuclear waste, is a suitable substitute for Co-60 as a radioactive source because of its longer half life (30 yrs). Nuclear Recycle Group has given special emphasis on utilization of Cs-137 for such applications. This will give societal benefits in addition to the revenue generation and will also address issues related to disposal aspects of High Level Radioactive Waste.

Though traditionally Cs as Cesium Chloride (CsCl) powder has been used in radiation source applications elsewhere in the world, CsCl is highly soluble in water and the powder can get easily dispersed resulting in release of activity under accidental conditions. It is thus desirable to use Cs in immobilized form, with good product characteristics, so that high degree of safety can be ensured during its use in public domain.

Historical Background

In accordance with the Policy of Closed Fuel Cycle, India had developed an expertise in vitrification of High Level Nuclear Waste (HLW) and industrial scale vitrification plants have been set up at WIP-Tarapur, WIP-Trombay and AVS-Tarapur for vitrification of the HLW. Further, during refinement of Indian Waste Management Policy, emphasis was given on separation of actinides and high yield radio-nuclides like Cs-137 from the nuclear waste. Ion Exchange & Solvent Extraction Processes had been indigenously developed for separation of Cs-137. Separation of Cs-137, major heat generating radionuclide in HLW, will be advantageous in terms of reduced radio-toxicity of the remaining waste and reduced heat load during long term storage of such waste. In-spite of having expertise in vitrification of nuclear waste, the main hurdle in manufacturing of Cs-137 source pencils was the controlled pouring of the vitirified glass in stainless steel pencils.

Initial efforts for making Cs-137 source pencils were based on the concept of preparation of small spherical beads and putting them inside the stainless steel pencils. However, difficulty in making uniform beads due to corrosive nature of the vitrified product and presence of voids inside the source pencil, the bead making concept was not pursued further. Subsequently, it was decided to make the Cs source pencils based on the concept of direct controlled pouring of accurately measured vitrified product into stainless steel pencils.

Evolution of Glass Pouring Technology

The simplified block diagram of the activities involved in production of Cs-137 source pencils is shown in Fig. 1. Among all, the controlled pouring of vitrified product into the pencils is one of the most important activities. Mainly three design approaches were attempted progressively for controlled pouring of the vitrified product into the pencils as shown in Fig. 2:

a) Glass Bead Method

Initial concept of making Cs Source pencils was based on the preparation of 1-2 mm dia. glass beads to be filled into the pencils. The nozzles having 1 mm and 1.5 mm diameter opening were used for making the beads as shown in Fig. 2(a). However, it was observed that the method was not a practical solution because of the following:

i) Very high temperature requirement at the tip of nozzle to initiate the glass pouring.

ii) After few cycles of operation, the nozzle bore was getting enlarged due to the glass corrosion.

b) Freeze Valve Method

In this method, the vitrified mass is poured by energizing the bottom freeze plug directly into the source pencils ref. Fig.2 (b), a process similar to being followed at WIP. Multiple trials were carried out with different sets of temperature cycles. However, it was found to be very difficult to achieve the control over the glass viscosity and quantity being poured. Moreover, glass thread formation, which was not acceptable, and difficulty in predicting the start and end points of glass pouring were the shortcomings of this method.

c) Mechanical Plug Method

In order to achieve a fine control on pouring, the process pot design was modified with provision of a mechanical plug and seat type arrangement. Subsequently, the design was fine tuned through progressive modification of the plug and the seat (refer Fig.2 c, d and e). In this design, the plug was actuated through a pneumatic actuator to start / stop the pouring of vitrified product into the pencils placed on Product Trolley. This design has resulted in the most successful option among all the approaches tried for controlled pouring with which the pencils can be filled appropriately without any spillage of the vitrified product.

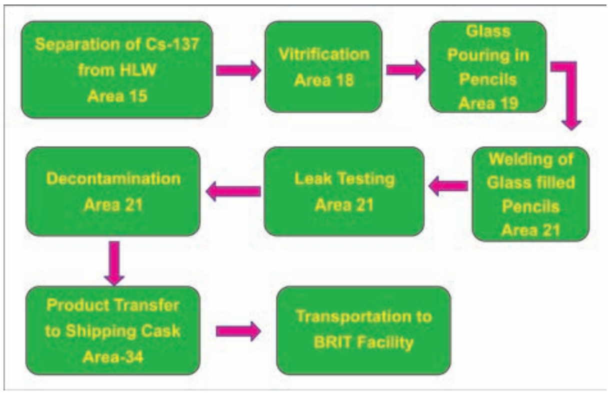


Fig. 1: Block Diagram of the Facilty

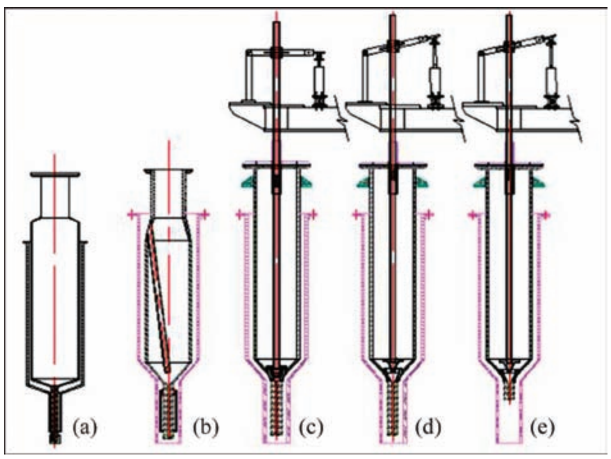


Fig. 2: Progressive Designs of Process Pot

Applications & Advantages of Cs-137

Cs-137 Source Pencils will have following applications:

- Blood Irradiation.
- Food Irradiation.
- Brachytherapy.
- Sterlization of Medical Equipment.

At present, BARC has targeted the development of Cs-137 Source pencils for Blood Irradiation application only. Advantages of Cs-137 as Radioactive Source over Co-60 Sources are:

- Reduced frequency of Source replenishment.
- Less handling and transportation.
- Less shielding requirement.
- Ready availability in nuclear waste.
- Reduction in radio-toxicity of remaining HLW.
- Reduction in heat load of remaining HLW, thereby resulting in reduced or no cooling requirements.

Present Facility

Technology Development Division (TDD) has rigorously worked on the critical aspects like design of mechanical plug based induction heated furnace which will ensure the controlled pouring of vitrified product at a temperature of around 950^0 C in SS pencils of 23 mm OD and 204 mm in length. The size of the pencil was dictated by the Co-60 source presently being used in the Blood Irradiators in India so as to keep the other dimensional parameters unchanged. The plant scale demonstration facility was designed to achieve the goal of direct controlled pouring of accurately measured vitrified product into these pencils. Subsequently, fabrication of all the required equipment and power supplies were completed and the demonstration facility was ready in March 2010. Full scale trials with various composition of glasses and simulated waste were carried out. After gaining the required confidence, through innumerable inactive trials, it was planned to install the plant scale facility for production of active source pencils.

Initially, feasibility studies were carried out in order to install the Cs Pencil making facility at the existing radioactive cells of WIP, Trombay. Subsequent to the feasibility studies, actual site measurements were carried out inside the radioactive cells. Further, the cell worthy set up was designed consisting of structure for Induction Furnace, compatible Inconel 690 Process Pot & Susceptor, Pneumatic actuation system, Product Trolley along with the Indexing arrangement, Load cell with appropriate shielding and flexible shafts to facilitate the placement of drive motors outside the hot cell. The main system, designed in a modular concept, with necessary remote handling interface has been installed in Area 19 of WIP, Trombay. WIP cask loading station has also been modified to facilitate the transfer of the active pencils to BRIT cask. The design has also gone through the safety approval processes through PLSC, ULSC and OPSRC route ensuring safety in all the stages of operations.

In general, the process of making Cs source pencils consists of vitrification of the separated Cs radioisotopes, dispensing of accurately measured Cs glass into the pencils, seal welding of the lid to the filled pencil, decontamination and transportation of the pencils to BRIT for end use in medical applications.

Sourcing of Cs-137 from HLW

Cesium-137, in appreciable quantity, is present in the high level radioactive waste. The presently available sulphate bearing waste has 2-3 Ci/l of cesium concentration. Apart from Cs, this high-level liquid waste at Trombay is characterized by the presence of strontium, actinides, high concentration of uranium and sodium. This waste is acidic (1-1.2 M HNO_3) in nature with average density of 1.2 gm/cm^3. The waste is subjected to partitioning by three cycles of solvent extraction to remove different radionuclides. The solvent extraction process involves, i) removal of U using a solution of 30% TBP in dodecane, ii) removal of Cs using Calix Crown Ether solution having concentration of 0.03 (M) CC6 in 50% iso-decyl alcohol and dodecane and iii) removal of Actinides and Sr using TEHDGA solution having concentration of 0.4 (M) TEHDGA in 15% iso-decyl alcohol and dodecane.

The raffinate from first cycle, lean in uranium, after adjustment of acidity is contacted with calyx crown ether solution to recover Cs from the stream at a processing rate of 100 lph. The Cesium lean HLW (raffinate) serves as feed for the third cycle for removal of actinides & strontium. The loaded organic, after second cycle, is subjected to stripping with DMW. The stripped product from second cycle, essentially a cesium rich solution, is stored. This purified Cs-137 product solution is further evaporated, concentrated and fed for vitrification of cesium in glass matrix for making source pencils. The composition of the purified feed solution is given in Table 1.

Table 1: Composition of Purified feed solution

Component	Concentration
HNO_3	3 M
Cs^{137} (as $CsNO_3$)	20 Ci/L

Vitrification

Cesium nitrate solution after evaporation in existing evaporator is fed to the melter for vitrification process. The processing steps involved in vitrification are evaporation, calcination, glass melt formation, soaking and draining. During vitrification Cesium nitrate of concentration 20 Ci/litre is added to melter as the feed solution in controlled rate. The vitrification is carried out as per the standard operating procedure of WIP with existing system based on predetermined temperature profile. Approximately 6 kg of vitrified product is poured in the Cs pencil process pot. The composition and properties of the vitrified product are shown in Table 2.

Table 2: Composition & Properties of Vitrified Product

Oxides	Wt (%)
SiO_2	28.8
B_2O_3	25.2
Na_2O	18.0
CaO	7.2
Fe_2O_3	9.0
TiO_2	1.8
Cs_2O	10.0
Laboratory pouring temp, °C	850
Pouring temp in plant scale, °C	900-950
Density, g/cc	2.5~2.7
Na leach rate, g/cm²/d	1.46×10^{-4}

Facility Description

The plant scale facility based on Solvent Extraction process has been operational at Area 15 of WIP, Trombay. In this facility the recently developed indigenous solvent, Calix Crown has been deployed by the Process Development Division. The steps involved in the production of Cs-137 based radiation source pencils are:

(i) Extraction of Cs-137 from HLW.

(ii) Immobilization of Cs solution in glass matrix in the existing melter of WIP.

(iii) Pouring of vitrified mass into the process pot of cesium pencil production facility (Area-18).

(iv) Reheating of cesium loaded glass matrix to pouring temperature in Area-19.

(v) Pouring of the Cs glass in source pencils in Area-19.

(vi) Welding and decontamination of pencils in Area-21.

(vii) Transfer of product pencils to BRIT cask.

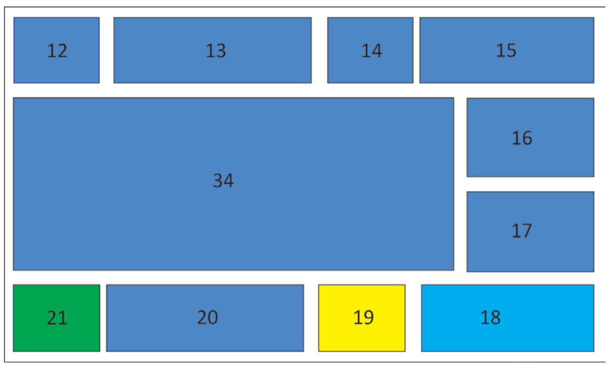


Fig.3: Schematic Layout WIP Cells

Table 3: Standard Specifications of Source Pencils

Sr. No.	Description	Details
1	Inner Pencil Dimensions	Ø23 mm, 204 mm long
2	Active Length	194 mm
3	Active Volume	70 CC
4	Sp. Activity of glass	1.78 Ci/g
5	Activity Content per Pencil	300 Ci
6	Lengthwise Activity variation	< 20 %
7	Outer Pencil dimensions	Ø25.5 mm, 210 mm long
8	Surface Contamination of outer Pencil	< 185 Bq

Induction Furnace

The induction heating furnace for cesium pencil facility comprises of Power supplies, Capacitor bank, High frequency bus bar and Coil assembly. This furnace has two (02) zones viz. 20 KW & 5 KW with separate power supply as shown in Table 4.

Table 4: Details of Induction Furnace Power Supply

Location	Power	Frequency
Zone-I	20 KW	5 KHz
Zone-II	5 KW	10 KHz

The capacitor bank for this furnace is made up of two sets of capacitors suitable for tuning 20 KW & 5 KW coils. The capacitor leads and copper connectors are water cooled and the electrical connections between capacitor bank and coil assembly is made up of high frequency bus bar.

Product Trolley (Area 19)

Product trolley is meant for receiving and positioning pencils below the induction furnace. The drives for the trolley and indexing are given through one of the wall penetration plugs through flexible shafts. This arrangement will enhance the operational life of the drive motors.

After re-melting of Cs loaded vitrified product its pouring into the source pencils of specified dimensions is one of the most important aspects of this facility. Small quantity and high activity of the vitrified product to be poured into the pencil have added to the criticality of the Product Trolley Design.

The Product Removal system mainly comprises of a locating trolley equipped with a pencil holding assembly and an indexing drive. The trolley has linear motion and the pencil holding assembly, mounted on the trolley, has rotary indexing motion. The trolley has been planned below the induction furnace and the pencil holding assembly can accommodate twelve (12) pencils. During filling of the pencil it has the provision of weight measurement of glass being poured. The material of construction of the Product Trolley is Stainless Steel (SS 304 L & SS 410).

The main features of the product trolley are:

1. Accurate positioning of the pencil below drain nozzle of the furnace through highly précised linear movement and indexing.
2. Minimum distance between Pencil top and the drain nozzle.
3. Accurate measurement of the glass being poured into the pencil.

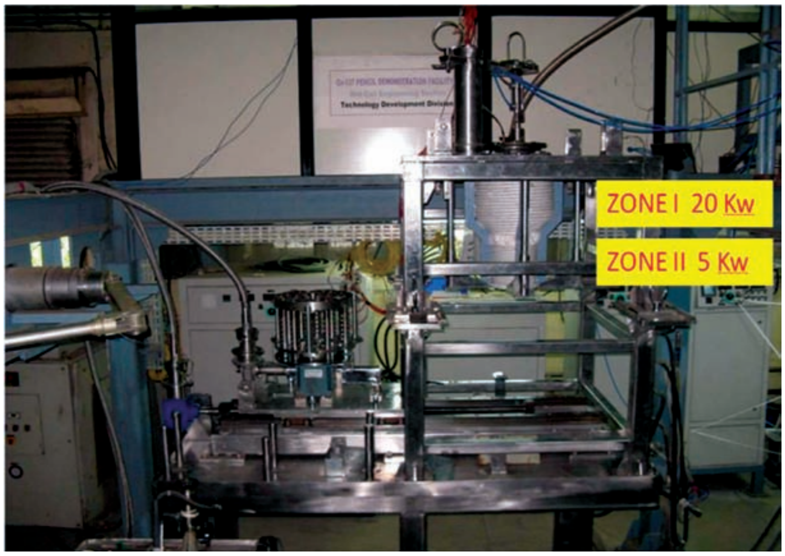


Fig.4: Inactive Demonstration Setup

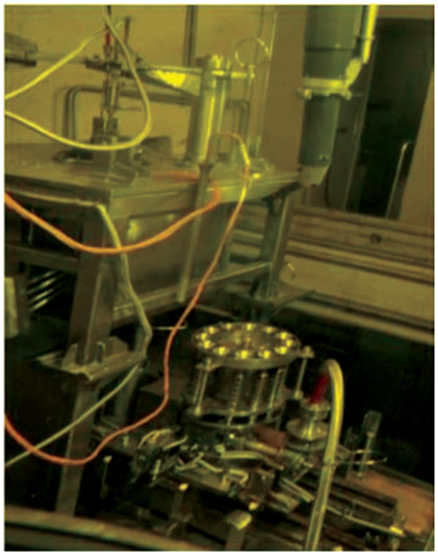


Fig.5: Setup Installed in Hot Cell

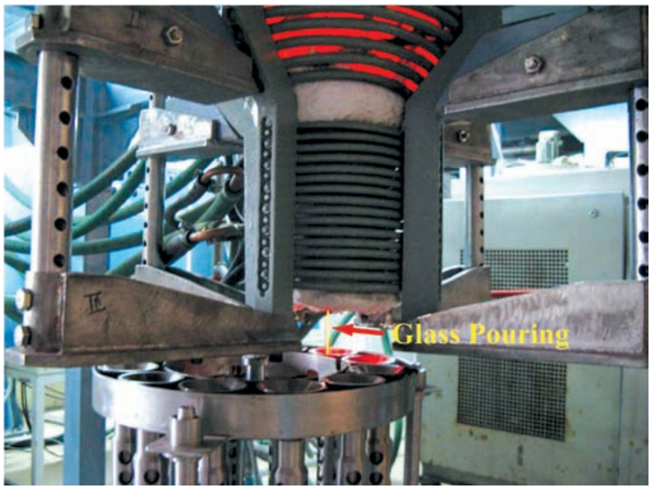


Fig. 6: Pouring of vitrified Product in Pencil

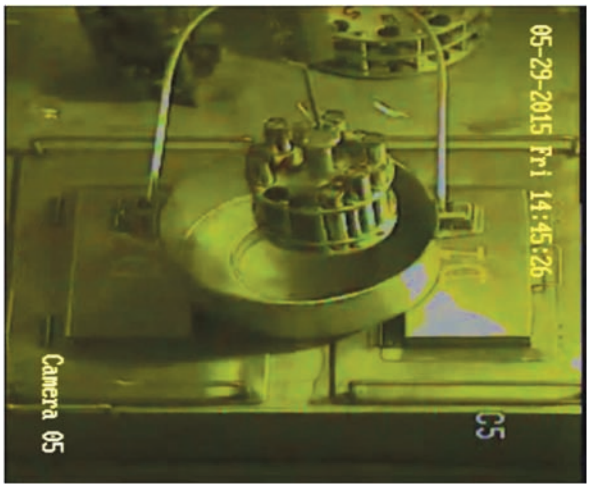


Fig. 7: Transfer of Source Pencils

Welding & Decontamination Station (Area 21)

The Welding & DC station has been planned in Area 21 of WIP. The decontamination baths, leak test baths and the Remote Welding Unit (RWU) have been installed on a platform within the reach envelopes of Incell crane and wall mounted pair of Three Piece Manipulators

The RWU is a special purpose autogenous pulse TIG welding unit meant for the remote welding of the lids of inner and outer pencil. The unit mainly comprises of a remotely replaceable welding head and the Power Supply. Considering the small size of the pencil to be welded, a rotary chuck has been provided along with a stationary electrode holder for this purpose. The camera and a suitable optical viewing system have been provided to check the weld quality.

Tests for Cs-137 Source Pencil

In order to deploy, Cs-137 Pencil as a radiation source in public domain, AERB has prescribed the following mandatory tests to be carried on each and every filled pencil:

a) Leak testing as per AERB/SS/3(Rev.-1) standard: Finished sealed source to be immersed (at least 5 cm below the level) in a water bath, which is maintained at a temperature between 90^0C -95^0C. Presence of leakage, if any, by way of bubble formation are to be observed for at least 2 minutes.

b) Loose contamination testing as per AERB/SS/3(Rev.-1) standard: Loose contamination on the sealed source is to be checked by taking swipe sample from outer surface of the pencil with a tissue paper. If the detected activity is less than 185 Bq, the sealed source is considered to be free from surface contamination.

Cask Support Platform

Cask Support Platform facilitates the accommodation of the BRIT cask in WIP Cask loading station for transfer of the source pencils, in specially designed transfer cages, from WIP Cell to BRIT Cask. Seal welded, tested and decontaminated source pencils have been planned to be transferred from the Area 21 to the BRIT Cask, placed outside, through this loading platform ref. Fig No. 8.

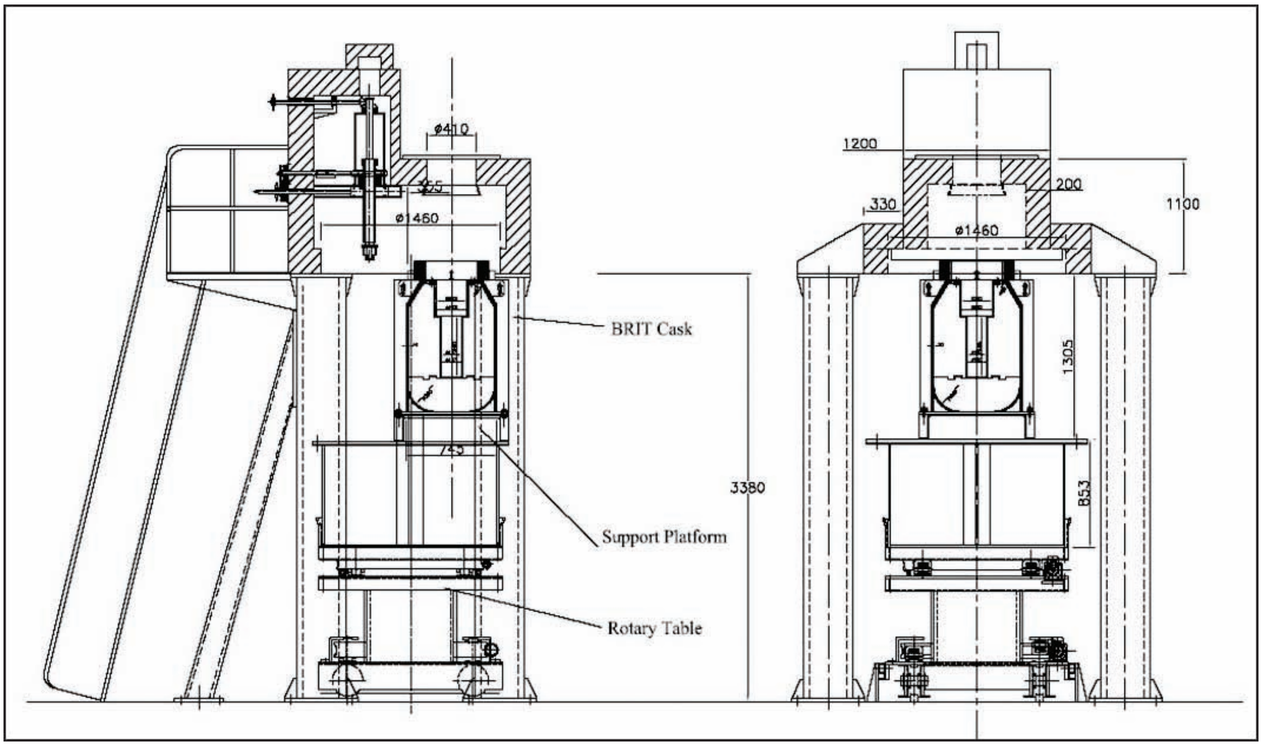


Fig. 8: Schematic of Cask Support Platform & Loading Station

Remote Handling & Dismantling

In view of very high specific activity of Cs-137 glass to be handled and radioactivity inventory inside the facility, remote operation and maintenance features have been considered while designing the systems of the facility. The dismantling scheme has been designed with the features of remote removal of each and every subsystems of the facility.

Master slave three piece manipulators having 20 kg payload capacity have been deployed to assist the in-cell crane for handling the source pencils inside the cell. The maintenance scheme has been prepared based on the remote removal of the trolley top as well as the full trolley itself. The furnace system has been designed with features such as remote removal of the process pot, susceptor and the thermocouples.

Production of Cs-137 Source Pencil

After completion of the installation work, three (03) incell trial runs were carried out to ensure accuracy of the mechanical setup and also to re-establish the control parameters along with the heating cycle. Finally, on 19th May, 2015 the active Cs loaded glass collected in the Cs Process Pot was re-melted in the Cs furnace as per the established temperature profile. After completion of the soaking process, the Cs glass was poured into the pencils (10 Nos.). Multistage pouring was done to fill the accurate quantity of Cs glass (170 g) in each pencil with the assistance of real time load cell data and timer. These freshly filled pencils were allowed to cool and subsequently transferred to the Welding & DC station wherein the lids were welded to these pencils. After passing the leak test, the pencils were encapsulated in the outer pencil and welding of the lids of these outer pencils was carried out. These outer pencils, now called as source pencils, were further leak tested and decontaminated as per the AERB guidelines before transferring and loading in the BRIT Cask.

On 1st June, 2015 Director BARC handed over ten (10) Cs-137 source pencils, having total activity of 2500 Ci, to the CE, BRIT. India has become the first country in the world to deploy Cs-137 vitrified radioactive sources in commercial domain.

Fig. 9: Cask containing Cs-137 Source Pencils

Fig. 10: Handing over of Test Certificates of Source Pencils to BRIT, Vashi

Acknowledgement

The authors are grateful to Dr. Sekhar Basu, Director, BARC, Shri R.S. Soni, Head TDD, Shri K. Banerjee, AD, NRG and Dr. C.P. Kaushik, CS, WMD for their invaluable support and continuous involvement. We are thankful to BRIT for their contribution in carrying out the tests for qualifying the prototype pencils as per AERB guidelines. The authors are also thankful to the present and past officials of NRG and other Divisions of BARC who were involved in this development activity.

Two day Seminar on Thermal-Mechanical-Hydraulic-Radiological-Chemical Experiments on Granites and Clays related to Geological Disposal of Radioactive Waste (TMHRC-15)

High level long lived vitrified radioactive waste loaded SS canisters/overpacks disposed at 400-500m depth in granitic rocks of a geological disposal facility trigger complex interaction and coupling of Thermal-Mechanical-Hydraulic-Radiological-Chemical processes (TMHRC) at depth in multi component system involving canister-glass-buffer smectite clays-granites-groundwater. A detail understanding of these coupling of these processes and their numerical modeling over extended period of time thus form key component of the safety assessment of geological disposal facilities. A two days NRG-BRNS seminar on laboratory scale Thermal-Mechanical-Hydraulic-Radiological-Chemical experiments on granites and smectite clays related to geological disposal of radioactive waste (TMHRC-15) was therefore organized during 21-22 July 2015 at Conference Hall, HBNI, Anushaktinagar. The seminar comprised two technical sessions with a total of 21 presentations.

The key objectives of the seminar were to provide a forum for discussion amongst in-house and leading national experts on various field and laboratory scale studies/experiments carried out in last three decades in the field of geological disposal of radioactive wastes in Indian case and identify focus area of research and development for next decade. The seminar mainly focused on measurement and modeling of complex TMHRCH processes that would operate around disposed high level waste canister in the depth range of 500-600m in suitable rock types. Technical Presentations made during the meeting included site selection and characterization, granite characterization at elevated temperatures, Importance of Underground Research Laboratory (URL), natural analogues of waste forms and repository processes, glass alteration and modeling, sorption of actinides and fission products on smectite clays, contaminant transport and modeling, impact of radiation and heat on barrier function of clays, numerical modeling of TMH processes using various codes, seismic considerations in geological repository, repository construction and design, international development in geological disposal projects, key URL based and lab scale experiments etc .

Dr R.K. Singh DS and Associate Director (Retd), RDDG, chief guest of the seminar, dwelt upon complicacy involved in up scaling of geo-scientific data from lab scale to field scale and also highlighted the challenges involved in TMHRC coupling and validation of results through experiments. Shri R.S. Soni, Head TDD delivered the welcome address and highlighted the importance of such experiments prior to field scale

Dr. R.K. Bajpai convener of the seminar giving welcome address

Dr. R.K. Singh Distinguished Scientist delivering key note address as chief guest

Seminar in progress

experiments in Underground Research Laboratory. Dr R.K. Bajpai, Convener of the seminar gave an overview of the latest international developments and progress made in the field of laboratory based TMHRC characterization and associated numerical modeling studies carried out on granites and smectite in Indian case. Shri R.K. Mathur & Shri P.K. Narayan, Ex Heads RES in their presentations covered progress made in last four decades in Indian Geological Repository programme. Dr Sumit Kumar RACD made elaborate presentation on sorption characteristics of smectite clays based on their laboratory based experiments. He presented first time data on sorption of Pu, Am, Sr, Cs and Na on Indian clays. Dr C.P. Kaushik CS WMD gave an overview of radioactive waste management in India. Dr D. Datta Head CRPC made an elaborate presentation on latest numerical methods for TMHRC processes including ANN techniques.

Dr A.K. Verma of Indian School of Mines, Dhanbad, Dept. of Earth Sciences and Prof. T.N. Singh, IIT Mumbai also made detail presentations on TMHRC modeling Indian reference disposal system using FLAC, PFC, COMSOL and other codes including cases of single and multiple canister and evolution of thermal fields. Dr R.K. Goel, Scientist In charge, Central Mining and Fuel Research Institute, Roorkee, explained experimental and modeling work carried out on Indian granites for their thermal and hydraulic characterization together with full scale repository thermal modeling results. Prof JP Shirvastava, Dept. of Geology Delhi University in his talk covered experimental studies carried out on Na borosilicate alteration using Parr Reactor and their comparison with natural glasses. He reported cases of natural analogues of waste glasses discovered for the first time jointly by Delhi University and BARC. Dr RK Bajpai in his technical presentation explained the key areas in the field of geological disposal of radioactive waste and various laboratory based experiments that need to be taken up in near future.

The seminar also included a panel discussion wherein expert panelists from BARC and other national institutes discussed the importance of TMHRC processes and need for development of technology and methodology through few key experiments in laboratory prior to their field scale versions in Indian context. The recommended experiments included block scale experiments on granite block of 60cmX60cmx60cm size with cocktail of tracers like Am-Pu-U-Sr-Cs. It was also recommended to conduct granite block scale radionuclide migration experiments to optimize the field scale tests planned in future. Expert panel also made recommendation to characterize all the smectite clay deposits available in India for their basic physico-chemical and mineralogical characteristics.

Technology Transfer

During the period between August 2015 and November 2015, BARC has transferred Ten technologies to various industries. Technology Transfer & Collaboration Division (TT&CD) co-ordinated these technology transfers. The details are given below:

A. "A rapid, continuous and renewable method for production of the anti-cancer drug Camptothecin" to M/s Sun Fruits Limited, Pune on August 13th, 2015.

This technology has been developed by Nuclear Agriculture & Biotechnology Division(NA&BTD). It is a Plant tissue culture method for the continuous and enhanced production of the anticancer quinoline alkaloid camptothecin using multiple shoot cultures of Ophiorrhiza rugosa var decumbens. The yield of camptothecin in the cultures is found to be 0.056 % dry weight during a period of 35 days and the parent plant contained 0.002 % dry weight.

Photograph after signing the agreement with M/s Sun Fruits Limited, Pune, seen from left to right Dr D. Fulzele, NABTD, Shri G Ganesh, Head TT&CD, Shri Shivraj Bhosale, Managing Director, Sun Fruits Limited, Dr Roja Gopalkrishnan, NABTD and Smt Smita Mule, TT&CD.

B. "H_2S Sensor with Monitor" Technology was transferred to M/s Precision Instruments &Electronics (Madras) Pvt. Ltd., Chennai on August 13th, 2015.

This technology was developed by Technical Physics Division, BARC. A highly sensitive and selective H_2S sensor with monitor (Model: TPD-BARC 1050) suitable for detection in 10-50 parts-per-million (ppm) range is developed. The sensor exhibits a response (Rair/Rgas) of ~ 500 (@ 50 ppm of H_2S) and is selective to H_2S with a meagre response (i.e. < 10) towards other interfering gases like NO, C_2H_5OH, CO, CO_2, Cl_2, SO_2,

Photograph after signing the agreement with M/s Sun Fruits Limited, Pune, seen from left to right Dr D. Fulzele, NABTD, Shri G Ganesh, Head TT&CD, Shri Shivraj Bhosale, Managing Director, Sun Fruits Limited, Dr Roja Gopalkrishnan, NABTD and Smt Smita Mule, TT&CD.

H_2 and NH_3. The sensor is coupled to a digital monitor that directly displays the H_2S concentration in ppm. The monitor has provisions for programmable alarm set points.

C. "Laser Screen Projectile Velocity Meter (LSPV)" Technology was transferred to M/s Theta Controls, Pune, on August 24th, 2015

This technology was developed by Laser & Plasma Technology Division (L&PTD) through incubation with M/s Theta Controls, Pune. The Laser-Screen Projectile Velocity Meter (LSPV) is a non-contact, stand-alone velocity measuring instrument based on time of flight principle. In LSPV, two parallel optical sheets, separated by fixed known distance, are used. It can be used as a tabletop standalone single instrument or with two parts having sensor unit near the projectile path and display unit at control room connected through fiber optic link. It is useful in Defense labs, for the study of material properties like deformation with known impact, to find out coefficient of restitution of a material and for college experiments on gravity.

D. "Fluoride Detection Kit for Ground Water (FDK)" Technology was transferred to M/s Transchem Agriland Private Limited, Vadodara, (Gujarat) on August 25th, 2015.

This technology was developed by National Centre for Compositional Characterization of Materials (NCCM), Hyderabad. This field-kit has been devised for quick and easy estimation of fluoride in ground water for establishing its suitability for drinking purposes. The cost per analysis works out to be nominal. The procedure is as simple as adding a specified amount of FDK reagent to the water sample to be analyzed and identifying the color developed. The color develops instantaneously and the distinction can be made with the naked eye. Water sample can be immediately categorized as being safe, marginal or unsafe for drinking from fluoride point of view. Generally this kit can be an excellent tool for individual/ community level identification of safe groundwater sources.

Photograph after signing the agreement with M/s Theta Controls, Pune, seen from left to right Shri V. K. Upadhyay, TT&CD, Shri Raja P. Mahbubani, CEO, M/s Theta Controls, Pune, Shri B.S.V.G. Sharma, Head, TT&CD, Shri A. S. Rawat, L&PTD, Shri S. N. Dutta, TT&CD.

Photograph after signing the agreement with M/s Transchem Agriland Private Limited, Vadodara, seen from left to right, Dr. Sunil Jai Kumar, Head, NCCM, Hyderabad, Shri S. N. Dutta, TT&CD, Shri B.S.V.G. Sharma, Head, TT&CD, Dr. B. N. Jagatap, Director, ChG, Ms. Rakhee Gupta, Director, M/s Transchem Agriland Private Limited, Vadodara, Shri Amol Pawar, Dy. Manager, M/s Transchem Agriland Private Limited, Vadodara, Shri V. K. Upadhyay, TT&CD, Dr. S. Rangarajan, WSCD, ChG.

E. "Preparation of Composite Polyamide Reverse Osmosis Membrane for Brackish Water (BWRO) Desalination" Technology was transferred to M/s Xpert Water Technology, Ahmedabad (Gujarat), on September 21st 2015.

This technology of was developed by Membrane Development Section, Chemical Engineering Group, BARC. Reverse osmosis (RO) is an efficient desalination technology for providing safe drinking water from brackish and sea water. Brackish water desalination is very common nowadays as most of the surface water available is brackish water. With proper collection and utilization, the reject stream can also be beneficially utilized. Membrane is the key component of the desalination process. BARC is engaged in the research and development of membrane preparation, assembling in different configurations and applications in various fields. Earlier BARC has developed and transferred the technologies for UF membranes. Technology for rolling of these membranes in spiral module has also been transferred. Present technology is developed for thin film based composite polyamide membranes and prototype 2512 spiral module. These membranes are capable of removing 90% salinity from brackish water (~feed concentration upto 3000 ppm). Using the developed technology, commercial size flat sheet membranes can also be made.

F. "Compact SMPS Based Triode Sputter Ion Pump Power Supply" Technology was transferred to M/s Kamal Engineering Works, Mumbai signed on October 19th,2015.

This technology of was developed by Technical Physics Division, BARC. This supply can be used with Triode Sputter Ion Pumps having pumping speeds up to 140 lps and for Thin film deposition by DC magnetron sputtering technique. Sputter ion pumps find extensive use in high vacuum systems where a "clean" vacuum is desired. They are used in scanning probe microscopy and other high-precision apparatuses.

Photograph after signing the agreement with M/s Xpert Water Technology, Ahmedabad, seen from left to right, Shri V. K. Upadhyay, TT&CD, Dr. A. K. Ghosh, MDS, ChEG, Dr. R. C. Bindal, Head, Membrane Development Section, ChEG, Shri Mehul H. Patel, Partner, M/s Xpert Water Technology, Shri B.S.V.G. Sharma, Head, TT&CD, Shri S. N. Dutta, TT&CD

Conventional Sputter ion pump power supplies tend to be heavy and bulky as they operate on the mains frequency viz. 50Hz. The compact switched mode triode sputter ion pump power supply made in BARC is based on a half bridge dc to dc converter operating at 20kHz resulting in a drastic size reduction of around 75% over conventional mains frequency operated ion pump power supplies. Our compact SMPS triode sputter ion pump power supply is rated for an open circuit voltage in the range of -6kV to -7kV with a short circuit current rating of 200mA. This supply can power triode sputter ion pumps of ratings up to 140 liters / second. A microcontroller circuit is used to display the various parameters, implement the Trip logic and provide a PC interface.

Photograph after signing the agreement with M/s Kamal Engg., Mumbai seen from left to right Smt. Smita Mule, TT&CD, Dr. Amar Banerji, TT&CD, Shri BSVG Sharma, Head, TT&CD, Shri Hiren Panchal, M/s Kamal Engg., Shri Ramesh Panchal, M/s Kamal Engg., Dr. S. M. Sharma, Director, Physics Group, Dr. S. K. Gupta Head TPD, Shri P. Abichandani, TPD, Smt N. B. Ved, Shri V. Perayya and Shri S. V. Choudhari from TPD.

G. "Arsenic Removal from Drinking Water Ultrafiltration Membrane Assisted Process" Technology was transferred to M/s Centre for Social Consulting India Pvt. Ltd., Mumbai, on November 24th 2015.

Arsenic (As) is known to be a very toxic element and a carcinogen to human. Even a trace amount of arsenic can be harmful to human health. The World Health Organizations (WHOs) current provisional guideline for arsenic in drinking water is 10 ppb. In India, states like Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam, Manipur, mainly in Ganga-Meghna-Brahmaputra (GMB) plain covering an area of about 569749 sq km with a population of over 500 million have reported serious illnesses due to presence of arsenic.

The arsenic removal from drinking water by physicochemical process provides process for decontamination of water with respect to arsenic. BARC developed know how of ultrafiltration (UF) based membrane technology for water decontamination with respect to microbiological contamination at both domestic and community scale is available for transfer separately. The present technology is a novel Ultrafiltration (UF) membrane assisted physicochemical process for removal of arsenic from ground/surface water to make the water safe for drinking.

Photograph after signing the agreement with M/s Centre for Social Consulting India Pvt. Ltd., Mumbai, from left to right, Dr. R. C. Bindal, Head, Membrane Development Section, ChEG, Shri Soumitra Kar, MDS, ChEG, Shri B.S.V.G. Sharma, Head, TT&CD, Shri S. N. Dutta, TT&CD and Shri Sanny Kumar, Director, M/s Centre for Social Consulting India Pvt. Ltd.

H. Nisargruna Biogas Technology based on biodegradable waste has been developed by NA&BTD. The plant processes biodegradable waste into biogas and weed free manure. It was transferred to the following parties :-

- The Duncan Hospital, Raxaul, Bihar on 07.09.2015
- M/s. SS Electrical Works, Kalyan on 02.11.2015
- M/s. LAHS Green India Pvt. Ltd., Thane on 09.11.2015

I. BARC through its Centre for Incubation of Technology has signed the MoU with M/s. Hari Krishna Exports Pvt. Ltd., Surat, (Gujarat) for incubation of "Development of Diamond Waste Powder Processing Methodology" on September 21, 2015

"Development of Diamond Waste Powder Processing Methodology", is suitable technology for conversion of process waste diamond particles into pure, sub-micron sized diamond powder. During the processing of natural diamond gem-stones, substantial amount of sub-millimeter sized raw diamond waste particles (CHURI) is generated, which is not suitable for conversion into marketable gem stones. This waste diamond is used for abrasive applications in other industries. On the other hand, ultra fine, micron-sized diamond powder is imported at a very high cost by diamond industry for polishing natural diamond gem stones. It is envisaged to convert the process waste diamond churi into micron/sub-micron sized pure diamond powder, which can be used for polishing purpose and serve as an import substitute generated out of the waste material. As per this incubation MoU, R&D efforts will be undertaken at Chemistry Division, to develop suitable technology. Initial experiments carried out at Chemistry Division, have been encouraging and further work is in progress with active participation of the incubatee (M/s. Hari Krishna Exports Pvt. Ltd.,).

Photograph after signing the agreement with M/s Hari Krishna Exports Pvt. Ltd., Surat, seen from left to right, Shri S. N. Dutta, TT&CD, Shri V. K. Upadhyay, TT&CD, Shri Ketan K. Parekh, Tech. Head, M/s Hari Krishna Exports Pvt. Ltd., Shri Sandip N. Sarvaiya, Coordinator, M/s Hari Krishna Exports Pvt. Ltd., Shri B.S.V.G. Sharma, Head, TT&CD, Shri H.V. Patel, Adviser, M/s Hari Krishna Exports Pvt. Ltd., Shri Pintu T. Dholakia, CEO, M/s Hari Krishna Exports Pvt. Ltd., Dr. B.N. Jagatap, Director, ChG, Dr. V.K. Jain, Head, ChD, Dr. V. Sudarsan, Head, MCS, ChD, Dr. Dheeraj Jain, ChD, Shri Jiten Nuwad, ChD.

J. BARC through its Centre for Incubation of Technology has signed the MoU with M/s Shrinath Ji KayaKalp Remedies Pvt. Ltd., Raisen, (MP) for incubation of "Development of Fluoride Removal Reagent" technology on October 09, 2015

"Development of Fluoride Removal Reagent" technology, is suitable for removal of fluoride from ground water. Fluoride contamination in ground water is a global phenomenon. Health of about 90 million people is affected due to presence of fluoride in ground water and nearly 16 Indian states namely Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Telangana and Uttar Pradesh are affected by this contamination.

A method has been developed at National Centre for Compositional Characterization of Materials (NCCCM), Hyderabad, to remove fluoride from ground water. The method is a batch method and has been tested at laboratory scale. In order to develop the technology for regular application, it needs to be tested in the field at larger scale. As per this incubation MoU, R&D efforts will be undertaken at NCCCM, Hyderabad, with active participation of the incubatee (M/s Shrinath Ji KayaKalp Remedies Pvt. Ltd.).

Photograph after signing the agreement with M/s Shrinath Ji KayaKalp Remedies Pvt. Ltd., Raisen, seen from left to right, Shri V. K. Upadhyay, TT&CD, Shri B.S.V.G. Sharma, Head, TT&CD, Dr. Sunil Jai Kumar, Head, NCCM, Hyderabad, Shri Pawan Maheshwari, Director, M/s Shrinath Ji KayaKalp Remedies Pvt. Ltd., Dr. B.N. Jagatap, Director, ChG, Shri S. N. Dutta, TT&CD.

MoU signed between BARC and SCL, Punjab

Bhabha Atomic Research Centre (BARC) signed a Memorandum Of Understanding (MOU) with Semiconductor Laboratory (SCL), S. A. S. Nagar, Punjab for development of 'Large area silicon detectors processing facility at SCL' on December 10, 2015. The 6" MEMS wafer processing Fabline at SCL will be augmented to take up fabrication of large area silicon based radiation detectors and the production of various detectors designed by BARC will be established under this MOU. Director E&I Group emphasised the need for production facility in India of silicon detectors required in various applications viz. compact radiation monitoring instrumentation, security imaging applications, medical and physics research. Director, SCL assured full support in achieving this.

The MOU was signed by Shri Y. S. Mayya, Director E&IG and Shri Surinder Singh, Director, SCL at RCnD Conference room, BARC in presence of senior officers from BARC.

BARC Scientists Honoured

- The Paper "Microscopic Origin of Net Magnetization in the Spin-1 Trimer Chain Compound $CaNi_3P_4O_{14}$" by A.K. Bera and S.M. Yusuf from Solid State Physics Division Presented in the DAE-Solid State Physics Symposium 2015 (DAE-SSPS-2015) held at Amity University, Noida, U.P. during 21-25 December, 2015 won the Best Poster Award.

- The Paper "Determination of thermo-physical properties of $(Th,Ce)O_2$ MOX using classical molecular dynamics simulations" by P.S.Ghosh, A.Arya, P.S.Somayajulu and G.K.Dey Presented in the International Thorium Energy Conference (ThEC-15) held at Nabhikiya Urja Bhawan, Anushaktinagar, Mumbai during October 12-15 2015 won the Best Poster Award.

- The Paper "Mock-up facility for AHWR fuel pin fabrication: A step towards fully automated fuel fabrication" by S.Panda, Saurabh Gupta, A.Saraswat,Vijay Ahire, Sanjeev Sharma, P.S.Somayajulu, K. Jayarajan Presented in the International Thorium Energy Conference (ThEC-15) held at Nabhikiya Urja Bhawan, Anushaktinagar, Mumbai during October 12-15 2015 won the Best Poster Award

- The Paper "Alpha Autoradiography Studies of Thoria- Plutonia Experimental Fuel for Pu Homogeneity" by K.V.Vrinda Devi, P.S.Somayajulu, J.N.Dubey, I.H.Shaikh, S.D.Raut, Jyoti Gupta, K.B.Khan and Arun Kumar Presented in the International Thorium Energy Conference (ThEC-15) held at Nabhikiya Urja Bhawan, Anushaktinagar, Mumbai during October 12-15 2015 won the Best Poster Award.

- The Paper " Characterisation of $(Th,Pu)O_2$ MOX fuel by analysis of Alpha images" by K.V.Vrinda Devi, J.N.Dubey, I.H.Shaikh, Jyoti Gupta, P.S.Somayajulu and K.B.Khan Presented in the NIT (Dr.B.R.Amedkar Institute of Technology), Jalandhar, Punjab won the Best Poster Award.

Modular Lab at BARC

Edited & Published by:
Scientific Information Resource Division
Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India
BARC Newsletter is also available at URL:http://www.barc.gov.in