Founder's Day Address

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By

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Dr Banerjee, Chairman, AEC, Senior Members of the DAE Family, Esteemed Colleagues, Ladies and Gentlemen,

It is my proud privilege to extend a warm welcome to all of you to the Founder's Day functions scheduled today, to commence with this morning's event here.

It has been our tradition to pay respectful homage to our Founder, Dr Homi Jehangir Bhabha, on his birth anniversary, the 30th October every year. The 102nd Birth Anniversary of Dr. Bhabha falls over the weekend this year and hence we are assembled here on this Friday morning for an introspection on our performance and achievements of the past year, as well as to rededicate ourselves to continue to do our best in providing the maximum benefits of all nuclear-related services to our nation and its very large population.

I will try to project a few glimpses of what BARC has achieved during the recent past, in various areas of our mandate, just to cite the typical range and nature of our work.

1. Research Reactors

The year ending December 2010 was a landmark year for the research reactors Cirus and Dhruva. The Golden Jubilee of Cirus operations and Silver Jubilee of Dhruva operations were celebrated in a befitting manner. All the reactors of this centre were

utilised well for isotope production, material testing, research and human resource development.

Research reactor Dhruva continued to operate with a high level of safety and availability of about 70%, in spite of the additional shutdown requirements this year for several upgradation tasks, that included the replacement of main control room panels and fuelling machine control panels by modern instrumentation. To take care of prolonged station black out scenario, trolley mounted diesel engine driven pumps have been commissioned and are maintained in poised state.

Dhruva continues to be the major facility for radioisotope production and national facility for neutron beam research. A total of 786 radioisotope samples were delivered last year. To further augment the radioisotope production, an additional tray rod has been incorporated. One hundred and twenty four samples were irradiated in pneumatic carrier facility for various research purposes. The facility continued to be utilised under the aegis of the UGC-DAE Consortium for Scientific Research and by a number of research scholars from various academic institutions.

After its permanent shutdown on 31st December 2010, the Cirus reactor has been defuelled and the heavy water moderator transferred to storage tanks. Various systems of this reactor are being operated in preservation mode.

Decommissioning of the Apsara reactor systems was completed. Acivities pertaining to building a new pool type research reactor with 2 MW(th) rated power at the site of Apsara are in progress. A recent evaluation has indicated that it will be necessary to construct a new reactor pool block, to be consistent with a design for increased static and seismic loading conditions,.

The basic design of the new 30 MW thermal High Flux Research Reactor (HFRR) has been completed.

2. Nuclear Power Related R&D

NPPs Under Operation and Construction

Bhabha Atomic Research Centre had successfully commissioned BARC Containment (BARCOM) test model at Tarapur last year. During the year, four sequential over-pressure tests culminating in the functional failure of the containment have been successfully completed. The results have been made available for post-test analysis. to fifteen Round Robin Participants, including 11 International Participants from seven countries. Such an extensively instrumented experiment has been done for the first time in the world.

An important finding is that, even after the functional failure of the primary containment, the leakage from primary containment with inherent tight cracks characteristics due to pre-stressing, the leakage rates are within manageable limits and the shielding cover will be retained in a stable manner.

Ultrasonic Phased Array technology has been developed to achieve better sensitivity and reliability in flaw detection and characterisation in critical nuclear power plant components such as PHWR pressure tubes, turbine blades, BWR pressure vessel and primary pipelines.

A test section for generation of two-phase pressure drop data for 700 MWe PHWR fuel channel components, including fuel bundles, has been installed.

Advanced in-service inspection probes were designed and tested for assessment of hydrogen ingress in pressure tubes. Scrape sampling for determination of hydrogen in operating pressure tubes was carried out in Kaiga-1.

An analysis has been carried out to study the behaviour of TAPS 1 & 2 under prolonged station blackout condition, to obtain information on gross behaviour of fuel temperature, RPV pressure, extent of clad oxidation and hydrogen generation during the progression of severe accident. Based on the analysis, the time line of the progression of accident was estimated and the findings indicated the availability of adequate time margins for external intervention.

The effectiveness of water Injection into moderator side to mitigate the consequences of Station Black Out was assessed for a large PHWR.

AHWR Programme

To assess the robustness of AHWR design against any foreseeable accident scenarios, an extensive exercise was carried out. It was determined that on account of its advanced passive safety features, accidents such as those at Fukushima, Chernobyl and Three Mile Island would have practically no effect on fuel integrity.

The experimental programmes towards evaluation of design margins for AHWR continued with setting up of several new facilities and conduct of experiments in the existing ones. For example, an air-water loop has been installed and commissioned to study various thermal hydraulic phenomena associated with the steam drum of AHWR.

The Critical Facility (CF) for Advanced Heavy Water Reactor (AHWR) was operated on fifty seven occasions for various experiments. Reactivity measurements due to loading of a cluster containing Thoria and uranium (Th-U) pins and (Th-1 % Pu) MOX fuel at various lattice positions were carried out satisfactorily.

HTR Related Developments:

Towards evaluation of alternate coolants for Indian High Temperature Reactor, a Molten Salt Natural Circulation Loop has been fabricated and installed to generate data on heat transfer and pressure drop. A computer code incorporating molten salt properties has also been developed.

3. Advanced Nuclear Fuels

Several new activities were carried out in BARC towards the development of advanced fuels for the FBRs, and the thorium fuelled AHWR. This work has covered the development of an innovative metallic fuel fabrication facility, characterisation of U-Pu metallic fuel and assessment of its compatibility with zirconium liner bonded clad material. We are also working on the development of cermet fuels for FBRs.

For the AHWR programme, ThO_2 –UO_2 pellets of different compositions having UO_2 from 8 to 22.5% were fabricated by powder metallurgy route. The evaluation of thermo-physical properties of these fuels is in progress. A new technique called Impregnation Agglomerate Process (IAP) for fabrication of thorium based mixed oxide fuel pellets using ThO_2 spheroids and uranium nitrate solution as the starting materials has been initiated, with encouraging results. The use of this process will reduce powder handling and associated personnel radiation exposure when Uranium-233 is handled.

The Post Irradiation Examination (PIE) of experimental thoria-plutonia MOX fuel elements irradiated in CIRUS Pressurised Water Loop was completed. The findings demonstrate better retention of fission products in irradiated thoria (relative to uranium oxide based fuel elements).

4. Reprocessing and Waste Management

Exactly one year ago, on the same occasion, I had announced the start of cold run of PREFRE-2 Reprocessing Plant at Tarapur. The hot run with spent fuel was inaugurated

by the Hon. Prime Minister of India on 7th January 2011. All systems in the plant are performing well and this plant is now producing plutonium for our programme.. Additional Waste Tank Farm has also become operational at Tarapur. Construction activities for reprocessing plant PREFRE-IIIA at Kalpakkam are progressing in full swing. Infrastructure development for first Integrated Nuclear Recycle Plant, Tarapur is in progress.

The remote decommissioning of first Joule melter (AVS-I) at Tarapur has been completed. The second Joule melter AVS-II is being taken up for commissioning. Various waste management facilities at Kalpakkam are going through cold commissioning.

The Plutonium Plant (PP) at Trombay and Kalpakkam Reprocessing Plant (KARP) at Kalpakkam also continued to operate safely and efficiently. In addition, processing of Thoria waste was carried out and modification and augmentation work at Waste Immobilisation Plant (WIP), Trombay was completed. In the field of R&D, one of our responsibilities is to recover useful materials from spent fuel, which is internationally a very advanced field of research. Towards this end, we have made important achievements during the year with demonstration of recovery of strontium from thorium lean waste and synthesis of associated specific crown ether. A process has also been developed for production of caesium specific crown ether. Advances were made also in the development of continuous rotary dissolver and cold crucible induction melter.

5. Environmental Monitoring and Radiation Safety

Assessment of the Impact of the Fukushima Event:

Using our computational models, preliminary estimates of the release rates of different radionuclides into the atmosphere and into the Pacific Ocean due to Fukushima Nuclear Accident were derived. Reasonable matching of the estimated release rates is observed with the values reported by different agencies.

All the Environmental Survey Laboratories in the country carried out special campaign to monitor very low level of radioactivity in the environmental matrices. The data from IERMON network was also analysed continuously at all the locations for atmospheric radioactivity. We were able to confirm that the Fukushima event has not caused any noticeable impact on India.

Monitoring of Environment :

Environmental Radiation Monitors with solar powered systems, and GSM and LAN based communication have been developed. Mass production of 250 units has been completed with the help of ECIL, Hyderabad. The units will be installed at various locations in the country under the Indian Environmental Radiation Monitoring Network (IERMON) programme of DAE.

Detailed baseline data for Atmospheric, Aquatic and Terrestrial Environment have been collected for the proposed BARC Campus at Vizag. Health and demographic status survey and marine survey, within an area of around 30 km radius, have been completed.

Instrumentation for Radiation Detection:

Inhalation dosimeter badges have been developed for directly monitoring the cumulative doses due to radon, thoron decay products using direct progeny sensors. These badges have been deployed in about 2000 places within the country and also in about 1000 locations in Europe, based on the request from several foreign institutions. Natural radiation burden from radon and thoron, especially in poorly ventilated dwellings is a known problem in several parts of the world, and the simple and effective development done at BARC is an important contribution.

6. Physical Sciences

Single crystals of copper and silver doped lithium-tetra-borate have been grown and they have been found suitable for dosimetry applications based on the optically stimulated luminescence technique.

7. Chemical Sciences

The feasibility study of in-house developed nano-diamond film as monitor of alpha activity of plutonium, in highly acidic medium, has been successfully completed.

A simple and inexpensive hydrogel-based material has been developed, which consists of nitrogen oxides releasing agarose gel, combined with citric acid loaded cotton gauze. It has excellent antimicrobial properties and has potential as a dressing material for ulcerative skin infections.

8. Biological Sciences

Towards developing radioprotector agents, an important finding has been made in experimental studies. 1,4-Naphthoquinone (NQ), a parent molecule for many anti-tumour natural compounds, protected lymphocytes and intestinal cells from mice against a dose of 4 Gy gamma radiation. In the mice, 2 mg/kg NQ given in-vivo restored radiation-induced bone marrow suppression.

9. Codes Development

A two-dimensional, multi-material Eulerian radiation-hydrocode, using Volume-of-Fluid tracking for material interfaces, has been developed, validated and applied to impact, penetration and ablative acceleration problems.

A code has been developed for generating equation-of-state (EOS) data covering orders of magnitude in density and temperature, necessary for radiation-hydrodynamics

simulations. High-accuracy EOS data for expanded states of metals, required for modeling exploding wires, has been generated using ab-initio atomistic simulations.

10. Food Technology

The browning of cut fruits and vegetables is reduced in irradiated fruits and vegetables. For the first time, in a study conducted on pre-cut ready to cook ash gourd, it has been shown that gamma resorcylic acid liberated from its precursor during radiation processing acts as a natural inhibitor of polyphenol oxidase, the enzyme responsible for brown discoloration of cut fruits and vegetables.

Chips prepared from potatoes irradiated for sprout inhibition showed relatively lower levels of acrylamide (compared to non-irradiated potato controls), which is a neurotoxin and a probable carcinogen.

11. Nuclear Agriculture

A confectionary class large seed Trombay groundnut variety, TG 47, has been released for commercial cultivation in the name of Bheema for early kharif and rabi under irrigated conditions in all agro-climatic zones of Andhra Pradesh.

BARC produced 470 quintals of quality breeder seeds of recently released varieties and distributed to several state seed corporations, national institutes, state agricultural universities, NGOs and farmers for further utilisation.

Nisargruna technology was developed in BARC not only for disposing bio-degradable waste in an environment friendly manner, but also to produce high quality manure and fuel gas very efficiently. This technology has been widely deployed in our country. During the past year, 25 more such plants have become functional. This technology has now been extended to process large quantities of biological sludge generated in

Effluent Treatment Plants (ETP) of textile, food and paper industries at Baddi (HP), Anjar (Gujarat), Kochi (Kerala) and Chandrapur (Maharashtra).

12. Isotope Applications

A dedicated 32 detector channel and Cs-137 radioisotope based process tomography imaging system, first of its kind in the country, was designed and developed in collaboration with the Indian Oil Corporation Limited (R&D Centre), Faridabad for applications in a packed cold-bed test reactor.

The first clinical use of BARC-produced Iodine-125 seeds for the treatment of prostate cancer was performed at the P.D. Hinduja National Hospital & Medical Research Centre, Mumbai on 29th September 2011 on a patient suffering from adenocarcinoma of prostate.

In collaboration with industry, radiation-grafted polypropylene based hydrophilic battery separator was developed by standardising various parameters. The separator was tested by the user industry and found suitable as a cost-effective import substitute.

13. Materials Programme

To qualify long design life of SS welds in advanced nuclear reactors (e.g. AHWR) and for life extension of existing reactors, the kinetics of low temperature embrittlement (LTE) was established for austenitic stainless steel welds. The electrochemical techniques developed to characterise the degree of LTE can be applied in a non-destructive manner and for in-situ use in plants.

In connection with the Indian contributions to the ITER project through Test Blanket Module (TBM) programme, BARC has developed pump-driven liquid metal loops for Pb-17Li and successfully operated them continuously for over 1000 hours. Pump and many of the key components for the loop have been fabricated in-house.

Towards commercial level development of Indian rare earth products, Nd-Fe-B alloy powder was synthesised for making permanent magnets in molybdenum crucible involving reduction-diffusion process.

14. Electronics & Instrumentation

ASICS

Three new ASICs - ANUSPARSH, ANUDRISHTI and ANUSUCHAK in 0.35 µm CMOS technology were designed, developed and tested successfully. The ANUSPARSH is front-end readout for Resistive Plate Chamber detectors of INO (India based Neutrino Observatory), the ANUDRISHTI is a monolithic photodiode and readout electronics for compact gamma detection probes and the ANUSUCHAK is low power front-end readout for silicon PIN Detectors.

To facilitate electromagnetic survey of deep seated mineral deposits, a Time Domain Electromagnetic (TDEM) system with 22 m dia transmitter coil and 1.1 m dia receiver coil has been tested using military helicopter DHRUVA of HAL for its airworthiness and found satisfactory. This is an important indigenous development to accelerate and support the expanded exploration of uranium in the country.

Face Recognition System:

Face recognition systems developed by BARC for access control have shown highly promising results (with only 0.7% false acceptance). This is of high importance for a variety of integrated biometric access control systems as defence-in-depth.

Differential Micro Barometer:

As an important import substitute, a Differential Micro Barometer to measure very small atmospheric pressure variations of the order of microbars around the mean atmospheric

pressure in infrasonic range has been developed. This important challenging development, benchmarked against intervening specifications in time-domain and frequency domain, has given highly satisfactory performance on evaluation under varying temperature and wind conditions.

15. Accelerator & High Power Electronics

Dual Energy Compact Linear Accelerator:

A 3/6 MeV dual energy compact linear accelerator for X-ray cargo scanning applications is in an advanced stage of development. The sub-systems consisting of a 85kV electron gun and its modulator power supplies, Linac cavity, magnetron source and modulator, focusing magnet, X-ray target and collimator have been developed and sub-system integration is in progress.

Electromagnetic Manufacturing System

A 20kV, 40 kilo-joule Electromagnetic Manufacturing System for use in cold welding of dissimilar metals has been developed. The system consisting of several special components and features will be used for joining FBR clad tubes of D9 alloy with SS end plugs, and future applications of joining ODS clad tubes and end plugs.

16. Advanced Technologies

Cryo-Technology

In-house developed micro cryo-cooler unit was integrated successfully with Hand Held Thermal Imager meant for night vision device to provide 250 mW cooling for the sensors at 77 K and handed over to EME School, Baroda, along with supporting hardware.

Desalination

Towards building indigenous capability for Thin Film Composite Polyamide membrane technology, the first batch of such membranes for reverse osmosis has been prepared and spirally rolled to commercial size elements. Six of these elements are now ready for replacing the membrane elements in reverse osmosis plant at NDDP, Kalpakkam.

17. Robotics and Remotisation

Automated Material Transfer System (AMTS)

An Automated Guided Vehicle (AGV) based material transfer system has been designed and developed in BARC. It performs continuous real-time assessment of demand for transfer of materials between various processing units in a manufacturing plant, and accordingly plans, prioritises and executes transfers autonomously. The system demonstrated to potential users, manufacturers and media will be deployed shortly on an experimental basis at Bajaj Auto Plant at Akurdi, Pune.

Four-Piece Servo Manipulator (FPSM)

Four-Piece Servo Manipulator (FPSM) recently developed by BARC is a novel design of servo manipulator, that can be used in place of any telescopic mechanical master slave manipulator. Using this easily maintainable FPSM, operators can handle objects in hot cells with less effort, compared to mechanical manipulators.

Contribution to Indigenous Teletherapy System

Prototype of a fully automatic, Multileaf Collimator (MLC) has been designed and developed for Bhabhatron-II telecobalt machine. The performance of the MLC was comprehensively tested on Bhabhatron-II telecobalt machine at ACTREC.

18. Societal Outreach and Technology Transfer

Technology Transfer

Two new technologies, namely, Quadrupole Mass Spectrometer and Dip and Drink Membrane Pouch were transferred to industry. Eight technology licenses to industry were renewed.

DAE Societal Initiative and Infrastructure Programme

i) Underground water source with capacity of 30,000 l/h has been identified, using Isotope Hydrology technique in a village called Nimkhed in Amravati District, a water-scarce area (under AKRUTI Programme).
ii) Tissue culture laboratory with field hardening facility of 50,000 banana plantlets has been made operational and first batch of hardened plantlets have been sown in the field in AKRUTI programme at Amravati, Maharashtra.
iii) A Brackish Water RO plant with 300 l/h capacity has been set up in a coastal village called Farare in Dapoli through AKRUTI programme. The villagers have been trained to operate, run and maintain the plant.
iv) To promote AKRUTI programme in the rural sector in a more structured way, BARC has signed MoU with Shri Vithal Education Research Institute-`SVERI' Pandharpur to set up DAE Outreach Centre in the form of Rural Human and Resource Development Institute (RHRDI) at Pandharpur in SVERI campus.

19. Medical Services

Medical Division, BARC is providing healthcare facilities to entire Mumbai based CHSS beneficiaries through its 390-bed hospital, 12 zonal dispensaries, 2 occupational health centers, and 24-hour Casualty facility. New facilities and upgrades continue to be added at the BARC hospital. The total number of beneficiaries as on 30th September 2011 stands at 87,080.

Dear Colleagues,

Coverage of the highlights of contributions by more than 15,000 persons, spanning across all scientific and technological disciplines, and even without a mention of our considerable role in the strategic domain, is impossible in a short time. All omissions in my speech are purely due to time constraints and do not in any way undermine the importance and the value of all such work.

The year 2011 has been a challenging year for the entire nuclear programme and industry, not only in India, but also the world over. This has been mainly due to the unfortunate events in Japan – Fukushima Dai-ichi that was a consequence of the unprecedented natural twin disasters - massive earthquake, (9.2 on Richter scale) , and Tsunami (of over 15 m height) - that struck Japan in March this year. While we need to remain fully cognizant and objectively responsive to these developments, it is imperative yet that we remain firmly committed to our well-established programmes and strategies based on our scientific and technological strengths and core competencies in the nuclear field. This is extremely essential to meet the country's growing energy demands as well as making sustained advances in the standard of living and quality of life for the society at large. Recent events have also highlighted the necessity to further strengthen our societal outreach programme. We are active in this direction and taking new initiatives.

We have recently finalised XII-plan project proposals for submission to the Planning Commission. The envisaged targets and plans can only be achieved by dedicated team efforts and multi-disciplinary collaboration and co-operation. I would like to reiterate that we have plenty of challenges ahead in effectively contributing to the envisaged massive growth in the nuclear power and radiation technology applications sector in the country. The history of our Department bears ample testimony to the fact of our coming on top of all hurdles that came our way through determination and strength borne out of our ingrained culture of self-reliance. With the synergetic effort of all of us , I am sure, we

can, and we shall rise to the occasion to meet these challenges in a manner consistent with our professional and cultural tradition.

Friends, on this very special day, let us yet again firmly resolve and rededicate ourselves to continue our pursuit of excellence and relevance in the frontier areas of nuclear science and technology for the betterment of life of our people.

Thank you – Jai Hind