64th Anniversary of the Independence Day
Monday, August 15, 2011

Address by
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Dear colleagues,

Let me first extend my greetings to you all on the occasion of the 64th anniversary of the independence day of our country. This morning, we have assembled here not only to take a collective pledge to preserve the honour and dignity of our national flag, but also to pay our homage to those who have made supreme sacrifices for the sake of freedom of our country. We also salute the members of our armed forces, who provide security to our country.

We take this opportunity to review our work and take stock of what we have achieved in the recent past. As you know, our mandate includes nuclear energy and nuclear fuel cycle, research reactor along with radioisotope production and isotope applications, different advanced technologies associated with these programmes, basic science and applied research, and strategic activities. Let me cite a few examples to illustrate some of the notable developmental work carried out and achievements made recently in our Centre.

1. Research Reactors

Research reactor Dhruva continued to serve as a major facility for radioisotope production and as a national facility for neutron beam research. As a part of the refurbishment programme of this 25 year old reactor, replacement of several major equipment has been completed. These include main Motor-Alternator sets and switch gears, channel flow monitoring gauges and I&C panels in the main control room.

The core of CIRUS has been fully defueled. Its process systems are kept under preservation mode.

Detailed engineering of various reactor systems of upgraded APSARA reactor is in progress. The upgraded reactor will provide enhanced facilities for beam tube research, radio-isotope production, calibration and testing of neutron detectors, material testing and bulk shielding experiments.

The conceptual design of a High Flux Research Reactor (HFRR) has been completed. This new research reactor is designed primarily to meet the large requirements of high specific activity radio-isotopes and to provide enhanced facilities for basic research in frontier areas of science and for applied research related to development and testing of nuclear fuel and reactor materials.

2. Nuclear Power Related R&D

Even before the accident at Fukushima, our reactor safety research programmes covered extreme internal as well as external event scenarios. A 1:4 Containment Test-Model of the 540 MWe PHWR (BARCOM), with extensive instrumentation was constructed and commissioned at Tarapur. The model was recently subjected to an over-pressure test when at 1.77 times the design pressure, the first milestone, viz. "first appearance of crack" was reached. The test data are being analysed as an International Round Robin exercise with four Indian and eleven foreign participating organisations from seven foreign countries.

Understanding the behaviour of buildings under relevant seismic loading conditions is an important aspect of plant safety. Through a major experiment on two large reinforced concrete structures, we found that the overall behaviour of the structures under seismic conditions can be closely simulated by a simpler push-over procedure. This finding will reduce the need for expensive shake-table test or elaborate non-linear dynamic analysis for seismic qualification.

On the process side, the effectiveness of water injection into moderator side as a Severe Accident Management Guidelines (SAMG) action to mitigate the consequences of Station Black Out (SBO) was assessed for a large PHWR.

The tsunami evaluation exercise for all the coastal sites has been underway since last three years and a National Round Robin Exercise has been carried out under this programme. A detailed analysis procedure has been formulated for local inundation mapping and analysis has been completed for Tarapur site.

AHWR Programme

Towards an early launch of AHWR project, the work for detailed engineering design of conventional engineering systems of AHWR has been started in consultancy mode.

Accident Management Analyses have been carried out for AHWR for some of the extreme events, including Large Break Loss of Coolant Accident, along with non-availability of Emergency Core Cooling System, together with loss of Moderator Heat Sink.

As a part of validation of the physics design parameters and the calculational models used for thorium based fuel, integral experiments with (ThO2- 1wt.% PuO_2) cluster and a mixed cluster consisting of Thoria and natural uranium have been performed in AHWR critical facility yielding valuable data relevant for design validation of AHWR. The fuel cluster was later loaded in a regular fuel position of Dhruva to study the irradiation behaviour of the thoria based AHWR fuel.

The experimental programmes towards evaluation of design margins for AHWR continued with the setting up of several new facilities and conduct of experiments in the existing ones. Innovative experiments to detect occurrence of critical heat flux in a new experimental set up were conducted to detect occurrence of this phenomenon.

3. Advanced Nuclear Fuels

PFBR Fuel Fabrication

Fabrication of the Mixed Oxide fuel pin for the first core of PFBR is in progress in Advanced Fuel Fabrication Facility of BARC at Tarapur. Laser decontamination of these pins has been incorporated in the process flow sheet. The use of laser decontamination system has reduced the exposure to operating personnel.

AHWR Low Enriched Uranium Fuel

As a part of development of LEU fuel for AHWR, ThO_2 –UO_2 pellets (300 Nos.) of different compositions having UO_2 from 8 to 22.5% were compacted and sintered in various atmospheres like, Ar, Ar-8%H_2 and N_2. The co-efficients of expansion of these fuel compacts have been determined. The evaluation of further thermo-physical properties of these fuels is in progress.

By utilising appropriate conversion-recycle-conversion (CRC) technique, a zero discharge of fluoride effluent has been achieved in U-metal production unit.

Development of advanced fuels for Fast Reactors

Vibro pack fuel

BARC has been working in the area of development of advanced fuels for fast reactors. As a part of this activity, plutonium rich mixed oxide microspheres of nearly 780 micron diameter were prepared for the first time in the world at BARC, by internal gelation method using sol-gel process. These microspheres, along with smaller size (around 100 micron) UO_2 microspheres prepared at IGCAR, will now be used as fuel material of a test pin for irradiation in FBTR at IGCAR.

Metallic Fuel

A glove box facility consisting of, injection casting of uranium/U-alloy rods in quartz tube moulds, demoulding of cast rods, end-shearing of rods and an automated inspection system, has been set up. This facility has been successfully used for fabrication of required numbers of natural U-6wt% Zr alloy metallic fuel slugs meeting required specifications. Continuous casting of uranium has been carried out successfully. This will help in reducing alpha waste during the fabrication of metallic fuel for FBR.

As a part of development of mechanically bonded metallic fuel for fast reactor, U-15%Pu slug has been fabricated for characterisation. The above alloy has been investigated for several of its relevant properties.

CERMET fuels

As a part of development of fuel for Fast Reactors, Cermet fuels comprising of 15% and 30% by volume of UO_2 dispersed in U metal powder were compacted and sintered at 1090^0C in Ar and vacuum. The shrinkage behaviour of the above cermet fuels were evaluated using a dilatometer. It was observed that sintering was superior in Ar atmosphere.

4. Reprocessing

Plutonium Plant at Trombay continued to operate safely and the irradiated fuel bundles received from Dhruva/CIRUS were reprocessed. In addition, Uranium Thorium Separation Facility (UTSF) was operated to recover thorium from thoria raffinate.

Reprocessing Plant at Kalpakkam was operated quite satisfactorily and safely. Under the Nuclear Recycle Board, the PREFRE-2, Tarapur Plant has started production. Additional Waste Tank Farm is also operational.

In order to realise the design through-put of future future large scale reprocessing plants, a full size prototype continuous rotary dissolver has been fabricated and installed. This unit will be operated under simulated conditions (with uranium nitrate) to generate useful data and provide feedback on various aspects such as material of construction, remote handling, recovery of material from hulls, etc.

For the first time in the country, a process has been developed for synthesis of Hydroxyl Amine Nitrate (HAN) to be employed as an alternate solvent in spent fuel reprocessing. The material has been indigenously produced up to litre scale.

Recovery of useful isotopes such as ^{09}Sr, ^{90}Y & ^{241}Am from radioactive waste was continued and supply to the users was maintained.

5. Nuclear Waste Management

Technology for remote dismantling and de-commissioning of Joule Melter inside hot cell was developed and decommissioning of Joule Melter System is nearing completion with very low man-rem expenditure and solid waste generation at the Advanced Vitrification facility, Tarapur.

At Waste Immobilisation Plant, Kalpakkam, inactive commissioning of second Joule Heated Ceramic Melter using simulated High Level Waste (HLW) was carried out. Remote replacement of components such as off-gas jumper, thermo wells, thermocouples and level probe has been achieved.

Vitrification technology employing Cold Crucible Induction Melter (CCIM) crossed another milestone by successful completion of simulated waste feed experiments.

A first time activity in DAE to retrieve, reduce the volume and dispose of the pressure tubes from the en-masse coolant channel replacement campaign of MAPS, has been taken up at the Centralised Waste Management Facility, Kalpakkam.

A process has also been developed for the synthesis of cesium-specific crown ether and indigenous production of the material upto kilogram scale. Inorganic ion-exchanger media, in bead form have been developed for removal of specific isotopes such as ^{106}Ru, ^{99}TC, ^{144}Ce from low and intermediate level liquid wastes.

6. Environmental Monitoring and Radiation Safety

Preliminary estimates of the release rates of different radio-nuclides into the atmosphere and into the Pacific Ocean due to Fukushima nuclear accident were derived using indigenously developed environmental models. Reasonable matching of the estimated release rates was observed with the values reported by different agencies. All the environmental survey laboratories in the country carried out a special campaign to monitor very low level of radioactivity in the environmental matrices. The data have been regularly updated in the departmental websites and communicated to the IAEA. We were able to confirm that this event has not caused any noticeable impact on India.

The solar powered Environmental Radiation Monitor (ERM) for open field installation was enabled with data communication facility using Short Message Service (SMS) of Global System for Mobile Networking (GSM), Local Area Network (LAN) and Optical Fibre Based Communication channels. These stand-alone automated systems transmit background environmental radiation data to a central station at Mumbai and serve as an early warning system, in case of a nuclear emergency due to an increased gamma radiation level in the environment. Industrial grade production of these units has been initiated under an MoU with ECIL.

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.

The R&D efforts to enhance safety during transportation of radioactive materials through public domain have resulted in successful development of Poly Urethane Foam (PUF), which is being further qualified for its use as thermal shielding and impact limiter in the transportation packages. Mapping of lead melting in real time was captured for the first time by adopting neutron radiography, using a dedicated beam facility at CIRUS. This experimental data will facilitate validation of computer codes used for modeling the behaviour of lead during the hypothetical accident of a spent fuel transport cask being engulfed in fire.

Two Emergency Response Centres (ERCs) have been established at IPR, Gandhinagar and RMP, Mysore with radiation monitoring systems and trained Emergency Response Teams (ERTs). This brings the total number of ERCs for preparedness and response to nuclear and radiological emergencies to 20 in the country.

Technical support was provided to National Disaster Management Authority (NDMA) for the preparation of guidelines on Preparedness and Response to Nuclear Disaster.

7. Physical Sciences

As a part of beam line development activity at INDUS, High Resolution Vacuum Ultraviolet beam line has been commissioned for spectroscopic study of molecules of interest to astrophysics and environment science.

The EXAFS beam line at INDUS has been augmented with fluorescence measurement facility for characterisation of surface, thin films and multilayers.

A quadrupole mass spectrometer, which has a resolution of 1 AMU and mass range of 150 AMU, has been fabricated and installed at Heavy Water Plant, Tuticorin.

8. 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.

The studies on bio-denitrification using mixed microbial granules showed that treatment of up to 4050 mg NO_3-N/L (equivalent to 18,000 mg/L NO_3) could be achieved by supplying acetate at a C/N ratio of 1.5. This was demonstrated in 6 litre volume laboratory scale sequencing batch reactors.

9. Biological Sciences

In a significant finding, 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 m/kg NQ given in-vivo restored radiation inducted bone marrow suppression. The possible mechanisms involve activation of redox transcription factor Nrf-2 (nuclear factor E2 related factor-2).

10. Food Technology

Acrylamide, a neurotoxin, and a probable carcinogen, has been reported to be present at significantly higher levels in carbohydrate-rich fried foods, such as potato chips. The compound originates from the reaction of amino acid aspragine with reducing sugars like glucose present in food during frying. The acrylamide content in chips prepared from potatoes irradiated for sprout inhibition, was found to be lower than that in the corresponding non-irradiated controls.

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 resorcyclic acid liberated from its precursor during radiation processing acts as a natural inhibitor of polyphenol oxidase, the enzyme involved in brown discoloration of cut fruits and vegetables.

11. Nuclear Agriculture

In the field of agriculture, two new Trombay radiation induced mutant crop varieties have been released. The first variety, named TAT-96-29, was released for cultivation in Maharashtra. Another large seed confectionary groundnut variety, TG 47 has been released as Bheema for cultivation in Andhra Pradesh.

Nisargruna technology has been successfully extended to process large quantities of biological sludge generated in Effluent Treatment Plants (ETP) of textile, food and paper industries. Four such plants were set up.

12. Isotope Applications

Investigations were carried out to quantify the Submarine Groundwater Discharge (SGD) occurring under various tidal conditions in Thiruvananthapuram coast, Kerala. Natural ^{222}Rn (half life = 3.8 days) was used as a tracer. The study will help in the judicious exploitation of groundwater in coastal aquifers by maintaining the seawater interface well within the coastal zone.

Our efforts towards development of Lutetium-177 based radiopharmceuticals have shown positive results. Currently, six nuclear medicine departments in India are using the high specific activity ^{177}Lu produced in the Dhruva reactor, for the preparation of ^{177}Lu-DOTATATE for the treatment of neuroendocrine tumors. India is among one of the seven countries which are pursuing ^{177}Lu based therapy for the treatment of cancer.

Sludge Hygienisation Research Irradiator (SHRI) facility, Vadodara has now been linked to the new 66 MLD sewage treatment plant that has higher solid content in the sludge.

13. Materials Programme

Processing maps have been generated on cast Zr-2.5Nb over a temperature range of 700^{o} to 1100ºC. On the basis of the data generated, forging has been carried out successfully on full scale cast ingots of Zr-2.5Nb by a manufacturer. This work was carried out in collaboration with Nuclear Fuel Complex, Hyderabad.

A new class of ferromagnetic shape memory alloys based on Ni-Mn-Sn system known to exhibit Inverse magnetocaloric effect was studied. Single crystals of the thermoelastic shape memory alloy Cu-16Zn-16Al were successfully prepared using Bridgmann methodology and soft mould technique.

A prototype of ITER Test Blanket Module (TBM) first wall is being fabricated by machining, bending and laser welding. Laser welding studies on ferritic martensitic steel P91 were carried out in this connection, followed by mechanical testing of the weld joints with and without a post weld treatment.

After successful augmentation of Phase-I part of Lithium Metal Plant, and after obtaining the regulatory clearance, the plant was operated for demonstration of its capability by achieving desired grade of lithium, required for the ITER TBM programme.

A large number of special shapes of vacuum hot-pressed beryllium have been fabricated as per the user specifications. These shapes have been accepted and are being used for neutron physics experiments.

14. Electronics & Instrumentation

Helicopter-borne Time Domain Electromagnetic (TDEM) system for aerial exploration of uranium ores was successfully flight tested recently. During this test, the underslung system, including 22 m diameter transmitter, was suspended 30m below the helicopter and 30m above ground.

Differential microbarometer to measure very small atmospheric pressure variations of the order of microbars around the mean atmospheric pressure, in infrasonic range, has been developed to facilitate its large scale production in the country.

Three ASICs - ANUSPARSH, ANUDRISHTI and ANUSUCHAK in 0.35 µm CMOS technology, and to be used in different detector applications, were designed, developed and tested successfully. The ANUSPARSH is a front-end readout for Resistive Plate Chamber detectors to be used in the planned Indian Nutrino 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 type Intrinsic and type detectors.

An Inertial Navigation System (INS) has been developed, that can be coupled to the Pipe Inspection Gauge (PIG) developed by BARC. Post processing of the INS data can accurately determine the 3-D layout of the pipeline. Trials of the system have been made in the test loop at the IOCL R&D Centre, Faridabad.

15. Accelerator & High Power Electronics

As a part of R&D programme for ADSS, studies were initiated to develop high intensity neutron spallation targets based on Lead-Bismuth-Eutectic (LBE) liquid metal. An LBE target module consisting of gas driven liquid metal circulation system with remote dismantling facility has been designed to couple with 30 MeV and 500 micro-Ampere proton beam for R&D studies. A target module has been fabricated for full scale trials with LBE before coupling it to the proton beam.

The 10 MeV RF Electron Accelerator at EBC has been operational and being used for several industrial process development. Irradiation of silicon power diode chips for BHEL at 0.4 kGy improved the reverse recovery time (Trr) of power diodes from 14 microseconds to about 6 microseconds.

A bipolar type six stage Marx generator of rating 300kV, 12kA, 300ns, 10Hz repetition rate with a Reflex Triode and reflectors for HPM generation was designed and fabricated. It has been operational and used for generation of high power microwaves.

16. Other Advanced Technologies

Computers

The latest parallel processing ANUPAM supercomputer, benchmarked at 47 Teraflops, and called “ANUPAM-Adhya” has been released to users.

Cryo-Technology

A significant milestone was achieved in the development of an advanced indigenous helium refrigeration system for cryogenic application. During operational trials, refrigeration power of about 500 W was achieved at 20K.

Desalination

Field test of BARC developed membrane based water purification system was carried out on tube well water for 24 villages in six districts of Punjab for removal of uranium from the ground water. Purified water containing less than 6 ppb uranium (which is far below the AERB permissible limit of 30 ppb) was produced from the raw water having 685 ppb uranium, The unit can be installed in homes and can be used as a point of use device with very low electrical power consumption.

Plasma Technologies

As a part of the development of dry processes for reduction of Uranum – Hexaflouride (UF6) to Uranium - Tetra Fluoride (UF4), thermal plasma assisted as well as flame reduction based bench scale setups were successfully designed, constructed and operated.

Pulse Power Technologies

A bipolar type six stage Marx generator of rating 300kV, 12kA, 300ns, 10Hz repetition rate with a Reflex Triode and reflectors for HPM generation was designed and fabricated. It has been operational at 225 kV and used for generation of High Power Microwaves in the range 1.2 GHz to 3.8 GHz.

Robotics

A gadget has been developed for automated cleaning of parabolic solar reflectors of size 1.8 m x 3 m used in the solar power plant. The gadget has recently been provided for field testing in a solar power plant near Pune.

Seismology

With the objective of promptly detecting, locating and identifying seismic events, including tsunamigenic earthquakes, several new analysis techniques have been developed and implemented at the Seismic Data Centers (SDC) of BARC. It has been demonstrated that from SDC, BARC, regional events located within a radius of 2500 km are, in general, reported much faster as compared to that by any other national and international seismological agencies.

17. Societal Outreach & Technology Transfer

An underground water source with a discharge capacity of 30,000 lph has been identified using Isotope Hydrology technique in a village called Nimkhed in Amravati District, a water scarce area. This water source has been established for use of farmers under BARC's AKRUTI Programme.

A 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.

A brackish water Reverse Osmosis (RO) plant with 300 lph capacity has been set up in a coastal village named Farare in Dapoli, through AKRUTI programme . The villagers have been trained to operate, run and maintain the plant.

AKRUTI Tech Pack, meant for rural sector, was transferred to five more parties. Two new technologies were transferred to the industry for the first time.

18. Medical Services

Our Vashi Dispensary is completely renovated and from March 2011 it is fully functional. Several new equipment have been procured for the BARC Hospital to facilitate its further modernisation and enhanced services to the beneficiaries.

19. Administrative Group

The administrative Group continued to provide vital supporting functions in the fields of administration, establishment, including man power planning, personnel data management, finance and accounts, and security.

20. Security & Physical Protection

Security of our Centre is of paramount importance. BARC security and CISF personnel have been performing a commendable task of providing the physical protection of our establishment. I take this opportunity to express appreciation of the BARC Fire Service personnel for their role in the protection of the various establishments of our Centre. I also compliment all officers and staff of our Centre for extending their cooperation to help the security personnel in discharging their duties effectively. I urge all my colleagues in our Centre to continue to remain vigilant and alert in the present environment.

21. Landscape and Gardening

The contributions made by the personnel of our Landscape & Cosmetics Maintenance Section is evident from the beautiful ambience of this venue. I take this opportunity to acknowledge their services.

22. Closing Remarks

Dear Colleagues,

I have attempted to give here only a few brief glimpses of some of our activities carried out by us during the recent past. Due to constraint of time, I could not cover many more, which are by no means less important.

In my speech last year, on the same occasion, I had highlighted the importance of continuing to maintain our excellence to meet the new challenges in the context of the emerging international co-operation. I would like to mention that our proposals for the forthcoming XII Five Year Plan, particularly address the realisation of this objective.

As you are aware, our programmes and deliveries directly address nearly all sectors of our societal needs, including food, water, environment, energy, healthcare, industry, education and national security. We now have a need to further strengthen the visibility of these deliveries to the society at large. We have already taken new initiatives to meet this need. I urge all members of our DAE family to contribute to our outreach and public awareness programmes with greater vigour.

Friends, finally on this very special day, let us firmly resolve and rededicate ourselves to continue our pursuit of excellence in the frontier areas of nuclear sciences and technologies for the betterment of the quality of life of our people.

- Jai Hind -