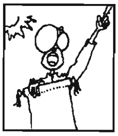

Glimpses of R & D Work in BARC

It was in December 1939 that the existence of nuclear energy came to be known to the world when the first paper on nuclear fission reaction was published in *Nature*. Even before the fact that the feasibility of a sustained fission chain reaction was demonstrated in Chicago was made known to the world, Homi Jehangir Bhabha initiated efforts in March 1944 to start nuclear research in India so that when nuclear energy is successfully applied for power production, India will not have to look abroad for experts but will find them ready at hand. The Tata Institute of Fundamental Research was started in 1945 with Bhabha as its Director. After India gained independence, on March 23, 1948 Prime Minister Pandit Jawaharlal Nehru introduced in Parliament a bill to develop and promote the use of atomic energy. While introducing the bill Pandit Nehru remarked "because of the powerful tools that atomic energy provides for unravelling and understanding the processes of life, because of the new weapons it gives for fighting disease and for the alleviation of human suffering, and because of the concentrated source of power it puts in our hands for peaceful purposes, man took one of the greatest strides forward in history by discovering how to release atomic energy." This bill was passed and became the Atomic Energy Act of April 1948. The Atomic Energy Commission was set up in August 1948. In January 1954 the Atomic Energy Commission decided to set up the Atomic Energy Establishment, Trombay which was

renamed as Bhabha Atomic Research Centre in January 1967.

The first scientist whom Bhabha recruited for the Atomic Energy Commission was a biologist. This illustrates the importance of biological research in the peaceful applications of nuclear energy. One of the first facilities that was set up at Trombay was the 1MW research reactor, Apsara, which became operational in 1956. Research in different branches of physics, chemistry and metallurgy were initiated as a part of the atomic energy programme under the aegis of TIFR even before the Atomic Energy Establishment, Trombay came into formal existence. Electronics is another area which is essential for the application of nuclear energy for any kind of nuclear research.

After Apsara, which is still in operation, BARC went on to build a zero energy experimental reactor named ZERLINA, a 40MW research reactor, Cirus, a plutonium fuelled fast reactor, Purnima-I, a 100 MW high flux research reactor, Dhruva, a Uranium–233 solution fuelled critical facility, Purnima-II, and a Plutonium fuelled mock up facility, Purnima-III, at Trombay, which was installed as a 30 kw neutron source reactor called KAMINI at the Indira Gandhi Centre for Atomic Research at Kalpakkam. The ZERLINA reactor was primarily meant to be a facility where the neutronics behaviour of different types of reactor lattices would be studied in order to refine the analytical tools used in the design of large research reactors and power reactors. After successfully using ZERLINA reactor for this purpose for about 20 years it was de-commissioned in 1984.

Basic studies aimed at gaining better understanding of nuclear fission and other nuclear reactions, use of neutron diffraction and neutron scattering to study a multitude of characteristics of different materials, irradiation of nuclear fuel assemblies in order to evaluate the performance of the fuel assemblies in a power reactor and irradiation of various materials in order to produce a variety of radioactive isotopes are some of the purposes for which the research reactors at Trombay have been used.

Physical Sciences: In BARC, there are strong research groups in a number of areas such as nuclear physics, lasers, solid state physics, crystallography, reactor physics, spectroscopy, seismology and gamma ray astronomy. The research reactors and the accelerator facilities built and operated by this centre have provided the foundation for the basic research that is carried out in many frontier areas of nuclear physics and condensed matter physics. BARC is also in the forefront of designing and building complete state of the art computer instrumentation for its various programmes in basic and applied research in physics.

Experimental nuclear physics programme utilises the Dhruva and the Cirus reactors, the 5.5 million volt van de Graaff accelerator, the 2 MV Tandem accelerator, the variable energy cyclotron in Calcutta and 14 MV pelletron accelerator at TIFR. Theoretical investigations to elucidate the structure of nuclei and for understanding a variety of reaction mechanisms are being carried out.

The original van de Graaff accelerator at Trombay was converted recently into a 7 million volt folded tandem ion accelerator (FOTIA), for more advanced studies. In condensed matter research, investigations using neutron beams from the Dhruva and the Cirus reactors constitute the major programme. A number of techniques have been developed. These include X-ray diffraction, laser Raman scattering, Mossbauer spectroscopy, gamma ray Compton scattering, positron annihilation, and Auger electron spectroscopy.

Using neutrons and X-ray beams, structural investigations of a variety of solids are being carried out, including those of biological importance. Neutron beams are also being used for the study of phonon spectra, elucidation of magnetic structures of solids and for dynamical studies of liquids and molecular systems. Positron annihilation and Compton profile studies are being carried out to understand electronic states in solids. Mossbauer spectroscopy is being employed for the study of cooperative phenomena as well as for corrosion studies. Laser Raman scattering investigations are being conducted for elucidating the nature of phase transitions in many solids. These studies are being supplemented by other techniques such as birefringence measurements and neutron scattering.

Facilities have been developed in BARC for carrying out investigations on solids under high pressure and on accompanying phase transitions. Theoretical studies have provided a new model for the equation of state in the difficult intermediate pressure region of 5 to 100 Megabars. The Centre also possesses good cryogenic facilities such as helium liquifiers, superconducting solenoids and cryostats to extend some of the measurement techniques to very low temperatures.

A variety of new devices and spectrometers for utilising the neutron beams available from the Dhruva reactor were built. These include hot and cold neutron sources, a guide tube laboratory and automated neutron spectrometers. A hallmark of condensed matter research activity has been an intense effort to indigenously develop sophisticated complex experimental equipment including lasers, computer controlled diffractometers and neutron spectrometers.

Excellent facilities are available at Trombay for high resolution spectroscopic studies. These are being utilised for the study of a variety of molecules in addition to spectral studies of rare earth ions. New band systems have been obtained for many diatomic and simple polyatomic molecules in microwave discharge and by flash photolysis. Fine structure analysis of the band systems has led to accurate evaluation of rotational constants. A vacuum ultraviolet Saya–Namioka monochromator has been built and is being used for carrying out spectroscopic studies of excited ions using tandem accelerator.

Chemical Sciences: Basic research in the field of chemical sciences is directed towards areas such as chemical dynamics, radiation and photochemistry, laser chemistry, interfacial phenomena, catalysis, radiation damage studies on organometallics, high pressure studies on materials, transport properties of metal oxides and hydrogen storage materials.

The interaction of high energy radiations like gamma rays, electrons and alpha particles in the MeV energy range with materials in aqueous and organic environment is a frontier area of both fundamental and applied importance. Work in this area has resulted in the development of new routes for radiation synthesis, catalysis, polymerisation, vulcanisation of natural rubber, etc. Development of radiation gelled and encapsulated biomedical devices for diagnosis and blood purification, pressure sensitive adhesives and diamond film deposition techniques are some of the significant achievements.

Dynamics of ultrafast reactions ranging from billionth of a second to trillionth of a second are studied to determine how energy deposited in a chemical environment is utilised for the purpose of chemical reactions, how the reactions themselves evolve and go through several intermediate stages and in what way the reactions and their energetics can be channelised in specific directions.

Development of high purity materials forms an integral part of a successful nuclear energy programme.

Analytical methodology has been developed for estimation of impurities present in parts per million or lower concentration in materials of interest in the nuclear programme using advanced techniques like neutron activation, mass spectrometry, atomic absorption and electroanalytical methods. Application of nuclear analytical methods to geochemistry, forensic science and for ultratrace analysis forms an important part of this work.

The continuing emphasis on both fundamental and applied aspects of chemistry has resulted in important spin-offs such as instruments based on gas chromatography including automatic process analysers, microsecond flash photolysis apparatus, temperature jump apparatus for chemical relaxation studies, electrochemical instruments and nuclear instruments for nondestructive assay, processes pertaining to heterogeneous noble metal catalysts for heavy water production, radiation processes for production of superfine metal powder, novel polymers and polymer composites including radiation grafting, and use of laser photochemistry for isotopic enrichment.

Basic studies in all branches of science and engineering are encouraged in BARC. Dynamics of ultra fast reactions taking place in billionth of a second, gas chromatography, development of bio-pesticides and food preservatives are all areas in which scientists and engineers work in BARC. Development of superconductor based magnets, liquid crystals, linear accelerators for medical and other applications, low temperature physics, memory alloys, biotechnology, development of new radiopharmaceuticals etc. are some of the fields in which BARC scientists work.

Computers are essential for any scientific work in the present day world. Getting numerical and analytical solutions to problems, simulation of various phenomena, and data capturing and processing need fast computers. Starting from indigenously available microprocessors, and using ingenious architecture, computer scientists in BARC developed a parallel processor based supercomputer which was found useful not only for solving problems on which BARC scientists are working, but also by the aeronautical engineers for simulating aerodynamics of certain new designs of aeroplanes.

Nondestructive testing and quality assurance in manufacturing processes are important activities in a nuclear power programme. Expertise developed by some of the BARC engineers and scientists in those areas are of such a high standard that other industries also call upon BARC for getting specialised service in these areas.

The motto of BARC is to support good work which is relevant to the nuclear programme, which includes power generation, utilisation of research reactors and use of radio isotopes; and to encourage research of high quality even if it is not directly related to the nuclear programme. Relevance and excellence are the key words in performance evaluation.

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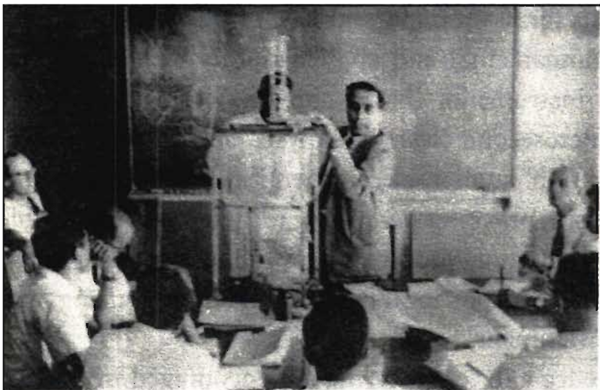

⇦ Bhabha Discussing the Design of the Apsara Reactor Control

R D Choksi, J R D Tata, ⇨ Homi Bhabha and Pandit Nehru