MY FOUR DECADES IN BARC



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I joined the Department of Atomic Energy in 1961 and superannuated in 2001. Our first year was a training period in the Training School of AEET (Atomic Energy Establishment, Trombay, later renamed Bhabha Atomic Research Centre after Dr. Bhabha's unfortunate and untimely demise). Sometimes I question myself, as to why I continued for so long at the same place?. I received several lucrative opportunities to migrate, settle in the US, France or Thailand. But I always got the same answer- a very high degree of job satisfaction; there were always new and exciting things (technical and non- technical) to do and in the process a lot to innovate at every step.

Joining Atomic Energy was not by design, though becoming an engineer was, because of the influence of my family. I did my schooling in Ambala and finished my matriculation in 1955 from the Punjab University. My uncle who was settled in Benaras (now Varanasi) proposed that after doing intermediate science, I should shift to Benaras; I would have an advantage in getting a seat in the Engineering College of the BHU which was considered a prime institute for Engineering during those days.

After my graduation in Mechanical Engineering, in fact, a day after the result was declared I joined my college as a teacher; it was a tradition to offer this position to the first few rank holders. At the same time, we started looking for suitable employment under guidance and advice from senior Professors. Those who wished to remain in the academic field were sent by the University to the US for pursuing M.Tech. I decided to join the Atomic Energy.

The first year was really a continuation of student life, attending classes and laboratory sessions, in addition to sports and cultural activities. My first interaction with Dr. Bhabha was on our Annual day celebrations where he was the chief guest and his mother gave away the prizes; being the Secretary of our batch, I was the compere.

After graduating from the training school, I joined the Reactor Engineering Division, BARC. We started studying different types of reactors and produced reports and also designed and established some experimental facilities, in the engineering halls and also around the three research reactors Apsara, Zerlina and Cirus. Though, the decision was taken to establish two BWRs (Boiling Water Reactors) at Tarapuron turnkey basis by General Electric USA, for the indigenous power reactor program, no decision had yet been taken, although it was argued that the natural Uranium heavy water route would

be more suitable for our country. Three countries Canada, France and the UK were pursuing the natural uranium, heavy water moderator route with different coolants. The coolant, in case of Canada was heavy water, for France it was gas and for the UK it was steam. Most of us who joined during those years were sent to Canada but some did go to France and the UK; I went to France. Very soon, it became clear that if natural uranium, heavy water moderator, route had to be followed for power reactors, the coolant also had to be heavy water. This is how we started our PHWR (Pressurised Heavy Water Reactor) program with Canadian collaboration for two units in Rajasthan.

When I was in France, Dr. Bhabha died in an air crash and we mourned the death of our founder. A couple of months after his death, all of us, the trainees from India in the Nuclear Energy Centre Saclay, were asked to assemble in a room and were informed that our 'Chief' was visiting the French Atomic Energy. We assembled but we did not know who the 'Chief' would be. We stood in a queue and introduced ourselves one by one. When the Chief approached, I said "Sir I am A K Anand from Reactor Engineering" and the Chief extended his hand and said "I am Vikram Sarabhai". His humility, simplicity and smile left a permanent impression on my mind. It proved that we were very lucky to have Dr. Sarabhai as the second Chairman of Atomic Energy.

I got my first challenging assignment in 1970; I was deputed to the USA for six months to participate in the 'reload fuel design' project, underway, at General Electric, San Jose for the Tarapur Boiling Water Reactors. I was lucky to get this responsibility of learning and later implementing the designs for future 'reloads' and help our Nuclear Fuel Complex in setting up facilities for manufacturing the fuel. After I came back, I set up the required facilities for their design and also helped the manufacturing team, even when they were trying to acquire suitable machinery for fabrication. While these activities were going on, a lot of fuel rods from a number of assemblies loaded initially, started failing prematurely and increased the radioactivity levels. A big 'reconstitution' program was launched to disassemble and reconstitute the old fuel assemblies till the new fuel was fabricated. This activity was done with remote tools, about six meters underwater. After my return from the US and being stamped as 'the fuel designer', I was posted at Tarapur for this activity. BARC team of 'post irradiation examination' experts, wished to have a look at some of these failed fuel rods. We had to overcome an international administrative problem and a technical one to transport the active fuel rods from Tarapur to the BARC through public roads. The Tarapur reactors are under safeguards and IAEA (International Atomic Energy Agency) Inspectors visited regularly while they could not visit BARC. As the enriched uranium content in the rods to be brought to BARC was small, IAEA approved their transfer. We used to have a lead shielded flask to transport Cirus spent fuel to the Plutonium plant. We quickly modified the same flask, so that it was capable of being handled vertically and horizontally and also capable of being aligned with the hot cells. We brought the fuel rods to BARC for examination. While we were busy doing all this, in 1974, we had the so called 'PNE' (Peaceful Nuclear Explosion). The international community, and the US in particular, were very sore and the regime of 'denial' to India started.

We started working on the Plutonium enriched fuel for Tarapur. My team also did some irradiation in a loop in Cirus, simulating power reactor conditions. Theoretically, we could get the required Plutonium by reprocessing spent fuel; alternately, our Chairman Dr. Sethna challenged the US to take back the fuel.

This, not only required a number of lead shielded heavy flasks which could float in case of a ship wreck, but also a 300 ton floating crane; thus the whole idea was dropped.

At this time, BARC announced an ambitious project of designing and making, indigenously, one of the largest research reactors in the world,;100 Mw thermal DHRUVA (named subsequently). The 'Group Leaders' of the Design team were selected from various Divisions and I was designated the Group Leader for the 'fuel design'. It was a unique management structure; every Group leader had at least two Bosses to report to and in addition, had to get his design cleared from other Group leaders; something like matching with the other components, designs for which, were also being evolved. Every Group leader had to do some R&D and testing, modify designs, resulting in, at times, another cycle of change. Despite these limitations we did commission the Reactor, but we were in for a big surprise. Vibrations were felt when we stood on the top of the Reactor, this happened when the main circulating pumps were started. It was decided to operate the Reactor for some time, observe the vibrations and collect data. It was concluded that the fuel rods were vibrating and rubbing against one another, wearing off the cladding and exposing the uranium resulting in increased radioactivity. It was clearly a sign of flow induced vibrations (some resonance) which were not experienced during the out-of-pile testing of the fuel inside the coolant channel, simulating the reactor conditions. I started getting advice from all to redesign the fuel, I was hurt and had a very disturbing period; the rumour mongers had a field day. I returned from a few days of leave and heard "Anand has resigned and left the country". The other most important 'Group Leader' was Anil Kakodkar, looking after the design of all internal structures of the reactor, including the coolant channel assemblies. We were both equally concerned as our prestige and the Nation's future nuclear program was at stake. Though we were irritated, at times with each other, we had (even now) respect for each other's technical competence. Along with my team, I started working on the design of different leaf springs to be located at the two support points to isolate the vibrations coming from the structure, while Kakodkar and his team started checking the natural frequencies of all the equipment, and trying to determine if the resonance was taking place. We both found answers at almost the same time.

While the above solution was being implemented on all fuel assemblies, I was given the most important assignment of my life; very few people are lucky to get this kind of an opportunity. Post the assignment in DHRUVA, I could not visualise what I would be doing in future. The post in Paris (DAE Science Counsellor in the Indian Embassy) fell vacant. I applied for the post along with a few others. A formal interview committee was constituted under the chairmanship of Dr. M. R. Srinivasan. Dr. Raja Ramanna was then the Director BARC; I was informed that I should not attend that interview as I am being designated as 'Project Manager' for the PRP (Plutonium Recycle Project), to be designed and built as a BARC Project in the DAE Complex at Kalpakkam. This code name PRP was for the 'Land Based Nuclear Propulsion Plant', for the future Indian Nuclear submarine program. Dr. Ramanna had already selected the site, along with his friend, Vice Admiral M. K. Roy, C-in-C, East who retired and took over as Director General ATV program; ATV (Advanced Technology Vessel/Vehicle) was the code name for the nuclear submarine program under the overall guidance and supervision of the Scientific Advisor to Raksha Mantri. For this project, a new 'Reactor Projects Division' was carved out of the existing Reactor Engineering Division and I was appointed the Head of this Division with only about a dozen Engineers as

the 'core' design team. This included Mehra, Grover, Basu and Yadav, who are all fellows of our Academy. It was decided to increase the strength, over the years, with input from the Training School and transfers from other Divisions as the work picked up.

The first task was to make a 'project report'. Three of us from BARC and four from the Navy, stayed at the DAE guest house in Kalpakkam for two weeks, with a make shift office room. We made the report, based on the data available, our estimates and gut feel. There was no authentic document available indicating the overall dimensions, speed and the horse power of the future nuclear submarine in mind. We arrived at the dimensions of the buildings and the crane capacities with hook heights, to house the equipment. The civil work started after the Chairman, Dr. Ramanna visited the site and signed a piece of paper which was hurriedly prepared by the Chief Engineer (Civil). Back in Bombay (now Mumbai), we started designing the Reactor Pressure Vessel, Steam Generators and Pressuriser and other reactor components. It was decided that BHEL, Trichy would establish facilities and manufacture this equipment; BHEL would also import material, specifications for which were generated jointly. Normal Government rules do not permit a Purchase order to be placed even on a Public undertaking without calling for quotations. We used to have a wonderful IFA in BARC, ShriBorkar. I explained the problem and the sensitive nature of the project; I also told him that establishing manufacturing facilities, procuring of the material etc had to go in tandem with design. There would possibly be mid-course corrections and some rework. Time and cost estimates could not be given but BHEL had promised that they would deploy all required resources to finish the job in the shortest possible time. Shri Borkar prepared a draft and gave it to me to write a note to the Director BARC, Dr. lyengar through the IFA. The matter was settled; BHEL would keep all the records, to be verified by IFA BARC, and get the expenditure reimbursed periodically.

Shri S. Basu, as the Engineer-in-charge, moved to the site with about ten engineers. There was a shortage of residential accommodation in Kalpakkam. This team commuted from Chennai for almost three years till we procured land and built a separate residential complex. The Team had expanded, and comprised of serving and retired persons from the Navy, a few DRDO Scientists and the majority from the DAE. For coordinating the activities from ATV, Nadaph was posted to the site, after the residential complex was commissioned. There is a lot of cultural difference between uniform-donning personnel and civilian scientists; we imbibed the best of both worlds and worked together; the motivating force being 'thrill of the project'. The design office in Bombay also expanded and a number of facilities were added at Bombay and Kalpakkam while ATV established their facilities in Hyderabad and Vishakhapatnam. A number of Scientists and Engineers from different divisions started working on the project; complete software and hardware for instrumentation and control were designed by the Reactor Control Division, headed by Govindarajan and the teams led by G P Srivastava and R K Patil; hardware was manufactured by ECIL (Electronics Corporation of India Ltd). The equipment for secondary systems like propulsion turbine, turbo generators, propulsion shaft, screw and the dynamometer was the responsibility of the ATV office while the hull was designed by the Navy's 'Submarine Design Bureau' initially headed by R S Chaudhry and later by R B Verma.

The first major equipment to reach the site was the hull sections and the bulk heads to be aligned and joined in the main plant building. At that time, an Admiral in ATV got an idea that the 'Command and

Control' of the PRP site at Kalpakkam should be taken over by the Navy. While we started discussing and arguing about the merits and demerits of the proposal, we did not let this controversy infiltrate down the line and work progressed as usual. I was asked to make a presentation to the then Chief of Navy, Admiral Vishnu Bhagwat; the only person who accompanied me was the DG ATV, Vice Admiral (Retd.) B Bhushan. Subsequently, Chairman AEC, Dr Chidambaram and SA to RM Dr. Kalam visited the site and the situation was diffused.

Mazagon Docks had been engaged in the manufacture of the conventional submarines and were invited to be yet another partner, for fitting secondary equipment, do the piping and weld hull sections. The remaining jobs were executed by BARC Engineers and at times, the designer came along with the equipment and returned after installation and testing.

By the time, I was due for superannuation, all the equipment had been installed and commissioned but the 'criticality' could not be achieved as the required number of fuel assemblies had not been delivered to the site. There was some mismatch in the timing of the expansion of our uranium enrichment plant. But soon after I retired, I got a phone call from Kalpakkam, that the reactor had become critical. I jumped with joy!

About six months before my retirement, while waiting to load the reactor with the fuel assemblies, I got another very important, additional assignment. For the past few years negotiations had been 'on going' between India and the Russian Federation to establish two VVER reactors of 1000 Mw each, at Kudankulam, but the contract could not be concluded as the cost was high and not acceptable to our Government. Our goal was to bring down the unit energy cost to the level comparable to the cost from conventional power station at that location. The Russians were insisting that the project would be built more or less on turnkey basis with hundreds of Russians stationed at the site and with very little Indian participation. Being familiar with LWR (Light Water Reactor) systems, in the beginning, I had been a part of the KK team when the Technical Assignment Document was drafted. CMD NPCIL, Dr. Chaturvedi sought permission from the Chairman Dr. Kakodkar, to give me an adjunct position in NPCIL, as 'Executive Director KK Project' so that I could become a part of his negotiating team. We had a number of negotiations and convinced the Russians that a lot can be done by us, thus increasing Indian participation to an extent that we achieved the commercial target set by our Government. I was a witness to the contract, signed in the Kremlin during the last month of my service in November 2001, in the presence of our Prime Minister Shri Atal Behari Vajpayee and the Russian President Mr. Putin during a visit of the delegation to the Russian Federation.

While I was writing this article, 'Kudankulam' became critical and four days after, I finished writing and was still editing, Criticality of the reactor on 'Arihant' was announced. What a satisfying span of life!