

**Recollections from my Service in the Indian
Nuclear Energy Programme - N.L. CHAR**

The Indian Atomic Energy programme can be said to have essentially started in the year 1955, even though it was conceived as far back as in 1948. It was in 1955 that a concrete step was taken to build an experimental nuclear reactor which is very essential for a comprehensive research and development programme in Nuclear Energy. The choice for such a reactor was the Swimming Pool Reactor, to be built in Trombay.

An engineering team was drafted early in 1955 for this purpose and I joined this team, headed by Mr. N.B. Prasad in June 1955. The other members of the team, at that time, were: V.N. Mechoni, V.T. Krishnan, D.C. Gami, G. Srikantiah, B.S. Magal and V. Ramachandran. Simultaneously, another group, headed by Mr. A.S. Rao was formed to design and execute the control and instrumentation for the SPR. This team had Mr. W. Pereira, as a leading participant.

Dr. Bhabha had decided that the project should be completed in one year's time and it should be a total indigenous effort - with the exception of the fuel, for which he had made arrangement with the UKAEA. This was a challenging task, and under the leadership of Dr. Bhabha everyone in the project team worked with full motivation, enthusiasm and total dedication.

The SPR project was only the first step, in the comprehensive programme, envisaged by Dr. Bhabha, towards achieving total self-sufficiency in Nuclear Power, with all aspects of the programme to be achieved by indigenous efforts. With this objective, a planned programme of drafting qualified scientists and engineers, metallurgists and others, and a special training programme for bright young graduates coming out of the Universities, had also been initiated by Dr. Bhabha.

While the design of the SPR was still in progress, I was deputed for an orientation course in Nuclear Science and Engineering, under President Eisenhower's 'Atoms for Peace' programme, at the Argonne National Laboratory, Chicago. It was a comprehensive course, covering all the aspects of nuclear energy, to be covered in a span of 7 months - which included class room lectures by eminent scientists, laboratory experience, and visits to many nuclear establishments in USA. I was the first participant, from India, in this course, and this was very beneficial for me for my subsequent work in our programme. Mr. G. Srikantiah was also deputed for a similar course conducted by the UKAEA, at Harwell.

When I returned from USA in July 1956, the construction work of the SPR at Trombay was in full swing and I rejoined the project team. The all-round hectic activity culminated in August 1956 when the first sustained nuclear chain

reaction was achieved and the SPR went 'critical' on the 4th August 1956. This was a proud moment for everyone in the project team.

Looking back, I however feel that it was rather unfortunate that the project was completed in undue haste, without the required proper attention being given for achieving quality in the construction work; the main objective seemed to be for achieving a political gain, i.e., to tell the world that India was the first country in the whole of Asia and the Developing world to achieve this feat.

As a result, we were obliged to shut down the reactor and dismantle it completely, because the pool was leaking profusely all over and the water was so turbid that nothing that was inside the pool could be seen, making it impossible to operate and use the facility.

A prolonged and extensive repair work was undertaken immediately to rectify these defects. The entire RCC structure of the pool was grouted under pressure by cement slurry, and the inside walls of the pool were painted with several coats of epoxy paint (although the earlier decision was to line the walls with stainless steel sheets). Experimental facilities such as the thermal column, shielding corner, beamholes etc and a maintenance facility of a dry-dock were also installed. Attempts at improving the water quality and the heat removal system were also made. It was a major effort lasting about a year and I was fully involved in this rehabilitation programme.

When the reactor was once again restarted, sometime in 1957, it was formally dedicated to the Nation by the Prime Minister, Jawaharlal Nehru, who christened the reactor as 'Apsara'. Mr. Meckoni was initially in charge of its operation and, after a few months, I took over the responsibility, when Mr. Meckoni joined the CIR team. I was with Apsara till 1958 when I was shifted to the Design group.

The period 1957 to 1960 saw a major effort being devoted in the construction of Trombay's second experimental reactor, the CIR, a joint collaborative effort with Canada. However, I was not involved with this project, except to give some orientation lectures to the members of the project team who were being sent for training in Canada.

The Reactor Engineering Division, after the SPR project, languished, till about 1962 without any substantial programmes, or proper direction and dedication, except for a small effort - the Zerlina Reactor - the construction of which was entrusted to me. A few examples of such wasted efforts are: a) Production of pure graphite for nuclear reactors (code name - 'Blackstone Project') b) research on gas-cooled heat transfer, with the aim of taking the lead from UK's nuclear power programme, c) organic cooled reactor concept, 'NUHMOC' along with research work on organic coolant heat transfer (which ended with a major fire accident in the heat-transfer loop and d) even an attempt at designing a 5 MW locomotive reactor!. These vague and

undirected programmes caused much frustration and disappointment among the engineers and staff in the group, resulting in flight of some good and motivated manpower, from the Engineering Division.

Around this time, the first step was taken for initiating India's Nuclear Power Programme, with the award of a contract to G.E (USA) to build the Tarapur Boiling Water Reactors, the much vaunted gas-cooled power reactor (of UK) option having been given up. The Tarapur Project, however, was not meant to be the fore-runner of a series of Boiling Water Reactors for the Nuclear Power Programme, since these reactors needed enriched fuel. It was intended more for a demonstration of economic viability of nuclear power in India, and to gain some experience in the operation of large power reactors. At this point of time, the Indian Nuclear Power Programme had not taken a concrete shape.

Towards the end of 1961 (or early in 1962) the Atomic Energy of Canada Limited (AECL) had evolved a viable design for a pressurized heavy water cooled, natural uranium fuelled power reactor (CANDU), for the commercial production of power from nuclear energy. It was based on their extensive experience in the operation of a Nuclear Power Demonstration reactor (NDP) at Chalk River. The first CANDU Power Reactor was to be constructed at Douglas Point, which would prove the design and be the fore-runner of a series of such reactors, for commercial production of electricity in Canada.

The Canadians entered the Nuclear Power market with their 'CANDU' design, in competition with the British and the Americans. This type of reactor, under the generic name of Pressurized Heavy Water (cooled) Reactor (PHWR) ideally suited the Indian Nuclear Power Programme which was based on the exploitation of Natural Uranium as the first step in the three phased programme of the eventual utilization of Thorium, through the Fast Breeder Reactor route. In spite of its very complex design features, the 'CANDU' type reactors had several advantages over the BWR type, such as on-load refuelling, and overall economy. The principal advantage of 'CANDU' reactors was, of course, the possibility of launching our own nuclear power programme, with the aim of nuclear independence. Moreover, the successful collaboration with Canada on the CIR project paved the way for a continuity in this relationship on a sound basis. Thus, a major decision was taken, sometime in 1963-64 for a long term collaboration with Canada in the development of PHWR's for the Indian Nuclear Power Programme.

The first commercial PHWR in Canada was being built at Douglas Point, on Lake Ontario, and in 1964, it was already in an advanced stage of construction. A comprehensive Indian team consisting of design, construction and operation engineers was sent for training in Canada, to be later placed at the Rajasthan Atomic Power Project at Kota. I, as a member of this team was trained for one year in the

erection of nuclear components consisting of the reactor, the moderator system and the primary heat-transport system, for one year. This was a very useful period for me and after return from Canada at the end of 1965, I was posted to the RAPP site. at Kota.

The RAPP project was not a 'turn key' project like the Tarapur Project. The project management was under the full responsibility of Indian Engineers, in all its aspects, including civil engineering, purchasing, tendering for site works and erection of all the systems. AECL had the responsibility for the design, project co-ordination, and supply of certain components and raw materials which were not available in India at that point of time, and the supply of heavy water. The agreement on the fuel supply was that Canada would supply 50% of the first charge of fuel and assist India in the manufacture of the remaining quality.

The spirit of co-operation and collaboration between Canada and India was excellent at RAPP, and the open and transparent approach by the Canadian Engineers was fully appreciated by the well motivated and enthusiastic Indian team of engineers. It was in this project that the DAE engineers, Indian suppliers and manufacturers and the site contractors fully utilized the opportunity, for the first time, to gain experience relating to the aspects of a major nuclear power project - such as, latest methodology of project management, planning, execution of site works to stringent quality levels, transportation of heavy and

oversided components, design analysis, quality control aspects, fuel fabrication etc. RAPP was to be the forerunner of a long-lasting collaborative effort between the two countries, to share the experience in the design, operation and development of PHWR's which had the potential of capturing a world-wide market. RAPP was the first step in this direction and can be said to be the fountain-head of knowledge in the DAE programme for nuclear power. Due credit has to go to Canada for this.

Personally, for me, the 5 1/2 years of experience at RAPP proved to be an eye-opener and helped me to absorb all the aspects of project management and execution to highest standards of quality and later, this enabled me to train many younger engineers in these fields. I consider this phase as the best part of my tenure in the DAE. It was with this first hand experience that I was able to shoulder the major responsibility of constructing the first Indian fast breeder reactor, the FBTR at Kalpakkam. After the completion of all the major nuclear components at RAPP-1, I was transferred to RRC, Kalpakkam as the Principal Project Engineer, for the FBTR project.

The Fast Reactor technology is quite different from the other types of reactors, because of the significantly higher temperature of operation, effect of fast neutron flux on the components and the use of highly corrosive and inflammable coolants like liquid sodium and sodium potassium alloys.

The Fast Reactor technology also calls for very special grades of stainless steels, and other materials, welding electrodes, very high standards of manufacturing technology and the most stringent quality management and control, at every step.

Among the countries that have a programme in Fast Reactors, the French have the largest experience resulting from extensive R&D efforts put in over many years. Seeing that the Indian Nuclear programme envisaged the eventual application of Fast Breeder Reactor technology, the French were quite keen for a collaborative effort with India in this programme.

Consequently, under an Agreement for co-operation between India and France in the Fast Breeder Reactor programme, a team of design engineers, headed by Mr. S.R. Paranjpe was sent to France to study the design aspects of 'Rhapsodie' reactor at Cadarache and to evolve a suitable design for a similar reactor in India. This team spent over a year in France and evolved the design of the Indian Fast Breeder Reactor (FBTR) with a major modification, incorporating a steam generator and turbine system, to utilize the power generated by the reactor and produce electricity. This team consisted of fresh, young engineers with adequate basic knowledge of design, but lacking practical experience to construct such a reactor in India. It was, therefore, assumed that the FBTR project would be essentially managed by a French team of engineers with the

young Indian engineers as under-studies. Most of the critical components were also to be procured from France. However, a joint team of French and Indian Engineers was also constituted to explore the possibility of getting as many of the components as possible, from India. This team visited most of the major industries (in the private sector) in India, but their conclusions were not much in favour of manufacturing the critical components of the reactor in India.

It is a matter of surprise that this team did not envisage the possibility of our major public sector industries, like BHEL, BHPV, HEC and BPCL, getting involved in this venture. Thus, the potential of these giant industries, some of which were already involved in the PHWR programme had not been taken into consideration.

I joined the FBTR group at this stage, to head the construction group. After familiarization with the design aspects, I spent about 3 months at Cadanache in France to study all the aspects of the Rhapsodie and Phoenix reactors and discuss, with the engineers concerned, the salient and important areas where extra care needs to be taken in building FBTR, based on the French experience.

With the project experience gained at RAPP, and the constant support and encouragement by Dr. Vikram Sarabhai for this project, I was convinced that the Indian industry would be capable of manufacturing almost every critical component of the reactor system, with proper inputs. The

special grades of stainless steels required, some forged components and a few other sub-systems and components only needed to be imported, along with the transfer of know-how for the manufacture and quality control. The construction at site could also be entirely managed by Indian Engineers with only a small team of French engineers stationed in India for co-ordination and consultation, but with no direct responsibility for the project management.

As the first step, I obtained Dr. Sarabhai's permission to explore the potential of Indian Public Sector Industries for manufacture of all the critical components, along with the private sector. It was, indeed, a revelation, after this exercise that almost every component could be made in India. BHEL units at Tiruchi and Hyderabad eventually turned out to be the major contributors in the public sector, along with the Walchand Nagar industries and Kirloskar Brothers group coming from the private sector.

As for the construction at site and overall project management, I was able to convince Dr. Vendreyas (representing France), at a meeting between him, the Chairman AEC and the Director, RRC, that the responsibility could completely vest with the Indian Engineers. The French, however, still wanted to keep their option open for the commissioning and operation stages of the reactor, by sending their team to India at the appropriate time.

Ultimately, this was also found to be unnecessary, since this phase was also successfully executed by our engineers, without the presence of the French engineers.

The technology and methodology to be adopted for the manufacture of the critical components of a Fast Reactor are a quantum jump from that required for the PHWR'S. Hence, it needed a complete re-orientation and re-education, even for those Indian industries that were already familiar with the technology of manufacturing PHWR components. A special team of project engineers from the FBTR group was, therefore, constituted by me and this team conducted a series of lectures, and discussion meetings at the various factories selected for the fabrication of critical components, imparting and educating their counterparts in the special aspects of FBTR. Also, during the manufacture of various components, an engineer from the FBTR group was also continuously stationed in the factories and workshops to liaise between the project group and the manufactures. Teams of quality control engineers, design and project engineers were also frequently visiting these factories at all critical stages of the manufacture and testing of the components. The response from the manufacturers were also very encouraging. This, indeed was the key to the success of the Indian project team in executing the project with a high percentage of indigenisation.

Training a team of totally inexperienced young engineers, and the workers, in every aspect of project

planning and management, construction, fabrication and quality control, for the FBTR, was quite a formidable task, but the task was made easier for me due to the total dedication, enthusiasm and motivation shown by these people, and adequate support from my superiors.

However, such a major effort undertaken by us, understandably resulted in long delays at all stages and the overall completion of FBTR, far exceeded the original targets. Another important factor that contributed to the delays and escalation of the project cost estimates was the great 'OIL SHOCK' of 1971/72 which resulted in the increase of all prices in India. But, inspite of this escalation, the overall cost of the FBTR project was still very low when compared with similar reactors constructed abroad. This was, no doubt, due, entirely, to the maximising of the indigenous content of the FBTR.

In the ultimate analysis, it is my personal belief that there was a net gain for India, in spite of the delays, in having acquired a full understanding of the Fast Reactor technology and in being able and ready to undertake the PFBR programme, without external help. The relevance of this aspect would become clearer, when viewed in the light of the watershed event of NPE in 1974 and the consequent isolation of our country from the Nuclear Powers, that be.