

Book Review

A Rare Insight into India's Nuclear Programme

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*Fire and Fury: Transforming India's Strategic Identity,
Anil Kakodkar, Suresh Gangotra.
Rupa Publications India Pvt. Ltd., 2019.*

Anil Kakodkar has done a signal service to popular understanding of India's nuclear complex by condensing his vast experience and deep insights in this invaluable book. He modestly calls his oeuvre a report card to his Gurus, citing the well-known story of Eklavya from the Mahabharat. The blurb reflects appraisals from eminent international and national experts and there is foreword by former Prime Minister Manmohan Singh. All have unreserved praise for the book.

Kakodkar offers the reader an intimate glimpse of how India's nuclear establishment has evolved and progressed over the past six decades during which he has been a key part of it. His book is unique in its transparency and focus on the density of the extensive work that went into making India a comprehensive nuclear power. The external environment that impacted this national enterprise, mostly adversely, does figure in the book but his purpose is more introspective - how his compatriots and he laboured to build the entire edifice, virtually from scratch and brick-by-brick, in diverse settings in BARC, IGCAR, NPCL and a host of institutions spread over the country. He does not hesitate to indicate the numerous handicaps that lay there, and the constant struggle to overcome them and to create.

Initial Years

He writes in first person and the narrative has an autobiographical prelude covering early years of severe hardship, growing up in a small town in Madhya Pradesh followed by relocation to Mumbai and joining the VJTI there for engineering education. After graduating from VJTI he was selected for BARC Training School in the nineteen sixties. His professional

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career commenced with topping his batch in the Training School. That also helped in getting his preference for joining the reactor design division (RED) at BARC. This offered a beneficial and lasting interface with, what he calls, "the type of nuclear power reactors (PHWRs) that would be the mainstay of the Indian nuclear program in the years to come". India's first nuclear power reactor was still some years away then.

Much to his consternation the initial task given at RED was developmental rather than design, and a specific challenge thrown to him was to get a metalizing gun operational in the Stress Analysis Lab where he was assigned. The metalizing gun would be used for ceramic coating, an essential process in multiple applications, not limited just to reactor engineering. He had to work alone on the shop floor acting as his own foreman, welder and supervisor, since his superiors felt that was absolutely necessary for success. As a mechanical engineering topper his account of how he struggled to meet this challenge effectively is interesting. It is germane to several chapters in this book where he tells how diverse engineering challenges came on the way and were duly met. These chapters are of immense value for a study of what comprised the backbone of indigenous capacity building in manufacturing and operating nuclear reactors through those difficult years. Kakodkar calls it "baptism by fire".

Later on, he wanted to register for Ph.D. in experimental reactor thermal hydraulics at a time when BARC had no scope for Ph.D. in engineering disciplines except metallurgy. It was possible to do doctorate in sciences, though. He made a consistent pitch to be allowed to do it but there were a number of hurdles in terms of rules and regulations. He felt that this route should be open to the engineers in BARC. Kakodkar contextualizes this by emphasizing that, "Comprehensive research covering all aspects, ranging from basic research all the way up to full scale qualification of technology and equipment, is a must in order to realize self-reliance in nuclear technology. Treating scientists and engineers differently is counterproductive for this purpose". He was sent to Nottingham University for a Masters in stress analysis but on return his own active engagement with many more key projects subsequently left him no time for a Ph.D. But he cherishes the professional turn that his career took towards 'much needed engineering development work'.

A unique feature of this book is that it gives the first-hand account of one of the most accomplished helmsman of the nuclear establishment. And this account embraces, with transparency and sincerity, the roller coaster trajectory spanning decades of the entire nuclear program covering full range of the fuel cycle, the dedicated personnel with diverse expertise and talent with whom the author collaborated and the institutions that came into being. The story comprises unrelenting engagement marked by camaraderie

and moments of isolation, synergy and argumentation at cross purposes and harmony over chaos in the 1960s and the Tarapore reactors, the design and erection of first batch of PHWRs (pressurized heavy water reactors), designing and commissioning of Dhruva, the challenges that came up in Kalpakkam and MAPs, the list is long. It is to the author's credit that in simple language without hyperbole he manages to give the reader a sense of the grit and perseverance with which he and his colleagues marched on. The reader also gets an idea of the nature of engaging interaction with the whole group of personnel engaged in numerous projects at different stages. The narrative does not shrink from revealing the tireless struggle that was put up against various odds.

Designing Reactors

For instance, one finds vignettes of big differences that cropped up about choosing right kind of design option for the research reactor Dhruva. The story about the trials and tribulations for setting up Dhruva is a compelling read. Likewise, about introducing Thorium in power reactors he illustrates briefly the obstacles and the problem. He was in favour of a configuration utilizing Thorium in the initial stages of PHWRs and, to this end, was able to work out an understanding of synergy between the physics and engineering disciplines in BARC. But in the nuclear fuel complex (NFC), in Hyderabad, there was considerable resistance when asked to fabricate a few Thorium bundles to be introduced for irradiation in the initial stages of PHWRs. This did not dim Kakodkar's conviction and his view prevailed ultimately, though only after change at the very top of the DAE. Later on, the concept and design of the Advanced Heavy Water Reactor (AHWR) evolved in which he actively promoted introduction of Thorium bundles. His considered view is that an AHWR 'has robust safety strengths of unprecedented magnitude' and requires lower level of technological infrastructure, which may be particularly relevant to developing countries. He stresses that construction of AHWR be taken up as a perfect response to safety and security needs of a much bigger role for nuclear power in a sustainable and clean energy mix.

A brief chapter on reactor repair and rehabilitation deserves highlighting. The author tells the tale of how one unit of RAPS was eventually saved from shut down at the fledgling stage of India's nuclear power programme. The Madras Atomic Power Station (MAPS) too had encountered serious setback owing to moderator leaks in the calandria. He was charged to deal with it in cooperation with a group of experts drawn from different parts of DAE, namely, NPCIL, MAPS, NFC (nuclear fuel complex) and BARC. The challenge was to first assess the damage and reasons for failure and then to strategize repairs and ensure appropriate safety for restarting the reactor. Vendor services for inspecting and repair of the high radioactivity innards of leaking calandria were explored in Europe with

limited success in the sense that while a French firm was found, it only facilitated better inspection but no possibility of repairs. Therefore, they had to mount indigenous venture within RED for fabricating instrumentation enabling remote robotic manipulation for repair work. Thereafter the rectification of the fault in the moderator circulation was also fully achieved by their team, where again considerable ingenuity was necessary to succeed.

The Canadian atomic energy giant AECL somehow got to know of the problem solving being done by Kakodkar and his group. They had actually devised a way of dealing with damaged inlet set up for moderator by attempting a reverse flow as a temporary fix. The Canadians strongly advised against the reverse flow solution and being the original collaborator for PHWR at Kota they were able to throw weight around among many of the members of the interdisciplinary team. But Kakodkar was hardwired enough in carrying through with the solution. After grappling with another hurdle the reactor resumed operation with just 25% power but it worked well. Later on, its power was raised to 50% (100MW). This breakthrough was a huge booster of morale for everyone around in MAPS and a big achievement.

Full 100% power was later restored for reactor operation with more systematic problem solving, which is spelt out in detail in this chapter. As for the Canadians, a separate generic problem is also mentioned. This relates to life management of the coolant channels in the heavy water reactors – India had seven of them. It required ingenuity in finding engineering solution. Canadians doubted Indian ability to deal with this challenge and even raised safety concerns at the IAEA. They already had a major incident involving coolant channel at one of their own reactors and dreaded that another incident would damage Canada's reputation as standard bearers of PHWRs. Kakodkar, however, recalls that there was great concern in India about forced-closure of operating units on grounds of safety. It was a real milestone in DAE's indigenous enterprise to resolve this coolant channel challenge successfully.

Comprehensive Work on Many Fronts

It is necessary to understand such nitty gritty of comprehensive work which the author has concisely explained in several chapters of the book before coming to the strategic dimension of the nuclear program. He is among the few who had the privilege of being involved with both sets of events about nuclear tests at Pokhran in 1974 and 1998, separated by 24 years. This book, therefore, has rare insights into the making of – what the title mentions – India's strategic identity. The pathways towards that goal are described succinctly but effectively in two chapters which cannot be further encapsulated as the

reader has to go through the accounts to get a better understanding of the process, the praxis and the achievements. It is still illustrative, however, to cite one anecdote from 1974.

One day, as he and his colleagues were proceeding from the base camp to work at the site in Pokhran, the jeep broke down mid way because its fan belt was torn. There was quite a distance yet to cover and arranging alternative transport would have taken them another three to four hours. Kakodkar decided to make a rope out of the shrubs that were growing around and made use of it as a belt. Thus remaining distance was covered without losing the day.

Critics might have their own take on it but this small anecdote going back 45 years bespeaks of the hard road travelled and the alertness to cope with any and every obstacle; from the very mundane to the sublime. On the substantive side the section on the nuclear test matrix for 1998 explains the problem about making the right choice from among the diverse weapon designs to be tested and how the final testing options were selected and executed. The achievements of those 5 tests on 11th and 13th May 1998 are described in copious accounts elsewhere too but this book mentions the essential gist very concisely and lucidly including regarding the thermonuclear test.

Kakodkar also devotes adequate space to narrate post-1998 developments in nuclear diplomacy at the highest level to address the ramifications of India's nuclear armed status; especially in mainstreaming India into global commerce in civil nuclear technology. His role and contribution in the extended parleys with US in forging a strategic partnership is well narrated and must be read *in extenso* to grasp the full significance.

In two chapters the author addresses appropriate institution building for teaching, research and technology as generic to emergence of India with unique core strengths, and the critical importance of creating rural wealth. These areas have been Kakodkar's preoccupation in his role as the nation's preeminent scientist and engineer after demitting office as Chairman of DAE. He says that Grameen Vikas or development of rural India is something that excites him. He describes in detail the concept of AKRUTI (Advanced Knowledge Based Rural Technology Initiative) developed by his colleague A.M. Patankar. Under this initiative scientists from BARC work in sync with NGOs "to familiarize villagers with a range of technologies developed at BARC that can make a difference to their livelihood". Simultaneously, there is the concept of Cillage (city +village) which aims to be a knowledge bridge between city and village. The last chapter delineates the contours of rural uplift through knowledge and technology empowerment of village youth. His pithy observation is worth quoting about rural-urban problematique. As he says:

"A notable feature of migration dynamic is movement of organic matter from farms to cities and inorganic matter from factories to farms in increasing quantities. This is causing problems of depletion of organic carbon in farm soils and increased bacterial pollution in air and water in urban areas."

The AKRUTI-CILLAGE initiative has been tried in three villages in Maharashtra and the experience thus far instills hope that it may be the way to attain self-sustainability in the long run.

In fact the book is full of many brilliant ideas. The concluding chapter on the way forward emphasizes energy security and climate change as twin challenges. His prognosis rests on inevitability of both nuclear and solar energy options to resolve the implicit tension between meeting energy needs of such a large nation while coping with climate change. He also feels Indian prowess in nuclear technology has much to offer for export and suggests that India become a manufacturing hub for nuclear equipment both for domestic and export needs.

Kakodkar has made very significant contribution as leader of the TIFAC project to prepare the technology vision for 2035 for India. The Technology Vision Document, he feels, has attracted attention both within the central and state governments and remains a work-in-progress.

The book has a personal piece by Suresh Gangotra who describes how inspiring it was working closely with Kakodkar in his office and his tireless schedule of working 24X7 between office and home. In the end there are brief intimate sketches by Mrs Kakodkar and his younger sister, Janhavi. They show the gentle, discreet and affectionate side of his personality. They bear out the truth of the simple verse of late Hindi poet, Maithilisharan Gupt:

जितने कष्ट कंटकों में है जिनका जीवन सुमन खिला
गौरव गंध उन्हें ही उतना यत्र तत्र सर्वत्र मिला

(Those who blossom going through a hard life full of thorns and pain; they alone attain the fragrance of that much renown here, there and everywhere).