A DREAM COMES TRUE

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I was born in a middle class large family in a remote village in the District of Bankura, West Bengal in 1954. My initial schooling was in the village primary school followed by high school in Bengali medium where English, Hindi and Sanskrit were taught from sixth standard onwards. My father was a school teacher in the High school and also had the added responsibility of managing the village post office apart from looking after the agricultural fields and running his charitable Homeopathic Dispensary. He was a simple, honest, hardworking person with the single motto of bringing up his children to the best of their abilities, sacrificing his own luxury and comfort. My mother was a homemaker with lot of love and care. Both of them taught us dignity of labour, honesty and dedication right from our childhood days.

I was an average student but passed out the Higher Secondary Examination in first class which was rare distinction for a village level school. I joined Garbeta Government College for BSc Honors course in Chemistry. Due to the turmoil of Naxalite agitation in West Bengal in the early 70's and frequent stoppage of classes in the college, my father suggested me to go outside Bengal for my studies. Thus I landed up in Varanasi to join the Institute of Technology, BHU for a 5 years B.Tech. course in Ceramic Technology discipline.

The first year was agonizing due to frequent ragging, not knowing to speak proper Hindi and waiting for the money order to come every month to get my pocket expenditure. However, I survived the ordeal and grabbed a merit-cum means scholarship and also managed to change my branch from Ceramic to Chemical Technology due to good score in the common curriculum for all engineering disciplines in the first two years. Thereafter the journey for the next three years in the Chemical Technology Department was smooth and memorable due to some wonderful professors whose teachings and guidance made me what I am today. I still fondly recall Prof.

Gopal Tripathi for Fluid Mechanics, Prof. NS Garg for Thermodynamics, Prof. Umashankar for Mass and Material Balance, Prof. Tewari for Reaction Kinetics.

After passing out B.Tech with Honors in Chemical Engineering in 1976, the option was to go for higher education or for a job. I opted for the former to give financial support to my family. Luckily quite a few job offers came in the way, namely, RIL, ONGC, RCF, INDAL and BARC. I opted for the last one on the advice of my father since it was a Central Government job and offers an opportunity to do work in a research oriented field in the frontier area of Science and Technology. I joined the 20th batch of BARC training and went through the one year rigorous training course in Nuclear Science and Technology with specialization in Nuclear Chemical Engineering. Thereafter I was selected as a Scientific Officer 'C' and joined the New Activity Section of Chemical Engineering and Technology group in BARC, Trombay campus in the year 1977.

It was a small multidisciplinary group under the dynamic leadership of Shri B. Bhattacharjee that my journey in the Department of Atomic Energy began. The group was assigned with the task of developing a process for enrichment of Uranium (increasing the concentration of 235 U from natural 0.7% to higher value say 3.5% 235 U for Light Water Reactors or > 20% for Nuclear Explosive Devices) wherein very little information was available in the published literature, a task that was considered near impossible for a country like India. The world enrichment at that stage was controlled by US, USSR, CHINA, FRANCE and UK through capital intensive gaseous diffusion process and the gas centrifuge process was in the initial stages of deployment in USSR, GERMANY, UK and Netherlands. Because of the potential of Enriched Uranium being used as a Nuclear Bomb (after Hiroshima & Nagasaki during 2nd world war) and to control the world enrichment market, the technology as well as all equipment and machinery connected with it were in the secret domain and embargo regime.

Under these circumstances, the quest for development of a suitable process for enrichment of uranium began in BARC, Trombay campus in the mid 70's. Initially it was scouring through scanty literature and patents that were available on the subject. After initial attempts on developing porous membranes and compressors for gaseous diffusion process, the focus was shifted to gaseous nozzle process, an aerodynamic process under development in Germany since it was a stationary wall device, easier to fabricate and experiment. However, development of critical components like Rotor, End caps, Drive motor, Bearings etc., for high speed gas centrifuge rotor continued in parallel since the gas centrifuge process offers higher separation factor and

consumes relatively little power. We were faced with numerous challenges right from the initial days. Vacuum technology was not taught in our engineering curriculum, but was an essential part of any of the enrichment process. Therefore we started learning about vacuum pumps, vacuum gauges and leak detectors. To design a vacuum system, we had to learn about suitable materials technology, type of joints and seals as well as welding technologies. A lot of effort went towards developing local vendors willing to manufacture and supply these components and systems. After initial learning of isotope separation technology through the separation nozzle setup using SF6 gas mixture, the focus got shifted entirely towards High Speed gas centrifuge process due to some promising initial results.

The initial breakthrough came in the form of a High Speed Rotor System with special bearing arrangement driven by a motor generator set. Gas entry and outlet scoops was arranged from the top through a hole in the end cap where there concentric tubes were inserted. Although the machine had a very short life, experiments on “U” isotope separation began with full earnest with in-house produced hex gas. With little or no experience in handling supersonic stratified gas dynamic inside a high speed rotor, the results were disastrous. But the tenacity to continue in spite of repeated failures and dogged determination to face the obstacles on the way soon got converted into a dream. In a short span of time we got an improved version of the High Speed Machine with pivot jewel non-contact bearing at the bottom and hysteresis induction motor drive as well as a molecular pump on the top. After struggling day and night for almost 3 to 4 years, the isotopic analysis of the product and waste streams showed that the high speed machine is truly capable of separating the ‘U” isotopes. Soon various design of aerodynamic scoops as well as temperature control at the top and bottom yielded better results. The challenge was to multiply the effect and get some significant quantity of product. This too was realized soon from a five machine square cascade operating in a recycle mode.

I was pleasantly surprised when a few of us got an invite from the then Chairman, AEC Dr. Raja Ramanna to join for a celebration dinner at the famous Taj Mahal Hotel at Gateway of India, Mumbai. It was a memorable event for a young engineer like me at that time but at the same time another dream was thrown into our mind; to build a gas centrifuge demonstration facility with few thousand machines sometime soon in the near future to qualify the technology as well as to produce some enriched uranium for various strategic applications of DAE.

During mid-80's the initial project work was initiated including identification of the site. We were still groping in the dark since the mechanism of separation inside the gas centrifuge was only partly understood and building a demonstration cascade of thousands of such machines working in a uninterrupted manner was a distant Dream. However, once again we started working, making P&I diagram, layout, equipment design, writing specification in a feverish manner.

Many a times, the entire work as thrown into the dustbin to rework with a more feasible idea. It's a difficult ball game to work on a R&D project with so many unknowns and so much of uncertainty. Additionally the difficulty in most of the multi- disciplinary engineering R&D project is that laboratory scale result are not enough, the concept must be proven at a scale where most of the engineering challenges are seen.

The Project site with an area of about 100 acres, was a barren piece of rocky land with hardly any green patches. We started visiting the project site from 1983-84, once the ground breaking started. Our first guest house cum office was an old bungalow type house belonging to the ancestors of Dr. Raja Ramanna. From 1985-86 recruitment of technical staff by holding interviews in the guest house started. We, a team about 10-15 engineers, were deputed to the project site to expedite the construction work and commission the project. In the initial years till the commissioning of the first cascade hall of the demonstration facility in 1990, the Project was under the administrative control of Indian Rare Earth limited, a PSU under DAE under the leadership of Shri R.K. Garg, CMD, IRE. We had to face a hostile neighborhood for almost a decade till we could convenience them about the zero discharge concept of effluent discharge to the environment from the project. Subsequently many of our outreach programmes and social welfare activities won their hearts.

By 1989-90, within five years from the inception of the project, the first cascade hall of High Speed Rotors was commissioned. However teething problems started arising one after another. The cascade could not be filled with hex gas since there was over pressure build up towards the enricher end and as a result machines were slipping away from synchronous speed. Occasionally machines will suddenly crash due to stress corrosion leading to leakage from vulnerable joints. The learning curve for cascade operation was very tedious and nerve breaking. By the time the teething problems were solved, the cascade life came to an end due to loss of a large number of rotors. But the lesson learnt out of this exercise revealed a lot knowledge about gas centrifuge

cascade operation which no published literature on the subject provides and gave us the confidence to go ahead.

The process of building capacity by adding more and more cascade of high speed machines continued over the next two decades under the dynamic leadership of Shri B. Bhattacharjee inspite of strict embargo regimes, which was tackled with intense Indigenous development efforts since early 90's. In house R&D gave us more and more advanced version of machines with higher and higher output and they were also inducted on the way in a phased manner. Indigenous development efforts paid good dividends particularly development of Special Vacuum Pumps and Gauges, Ultra Low Pressure Drop Mass Flow Meters, Hermetically Sealed Compressors, Helium Mass Spectrometer, Leak Detectors, Special Bearings, Molecular pumps etc. The production of indigenous enriched uranium opened up many frontiers of application which were not considered feasible earlier due to conditionality that comes with imported material.

A two-pronged expansion strategy was worked out during the silver jubilee celebrations of the project in 2009 under the guidance of Dr. Anil Kakodkar as Chairman, AEC and Dr. S. Banerjee as Director, BARC. An expansion of the existing Rare Materials Project during the XI and XII plan to take care of immediate needs of DAE and a long term commercial project plan at a new location to cater the fuel needs of Nuclear Power sector like AHWR/ &IPWR and even imported PWR's.

The expansion project executed under the leadership of Dr. Banerjee is in the final stages of completion where commissioning activities have started. For the other long term objective a suitable land with an area of about 1800 acres has been acquired and first phase of project activities for building up the new facility has started after obtaining the Environmental clearance from MoEF.

I have superannuated from service during March 2014 with a sense of pride and fulfillment of a life time dream of taking up a technical challenge and bringing it to a successful stage from where it can flourish further and serve the needs of the nation. We feel proud that this project is based entirely on 100% indigenous technology, a truly made in India product. Over the years I have built a team of competent and dedicated scientists and engineers, who I am sure, will carry the torch forward and bring more laurels for DAE and the country as a whole.

I would consider myself lucky for being able to fulfill my deferred ambition of completing my higher education - PhD in Engineering Science from Homi Bhabha National Institute during February 2014 and also to continue serving the department as a Raja Ramanna Fellow after superannuation.

I shall fail in my duty if I do not acknowledge the support and mentorship that I received all through my career in DAE in achieving my dream from my colleagues and Gurus. I also thank my family for supporting me in all my endeavours, particularly my wife Smt. Debi and sons Gaurav and Saurav. Lastly, I acknowledge the support given by DAE in offering me the Raja Ramanna Fellowship to continue my intellectual pursuit that enabled me to write this article. Last but not the least, I thankfully acknowledge the contributions in drafting and typing the article by my erstwhile colleagues namely Shri R. Ravindra Kumar, Smt. MS. Pushpa and Shri B Pradeep.