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Total technology development and delivery

It is generally not known that some eminent Indian scientists played an important role in promoting industrial production through research. C V Raman, committed to excellence in all fields and to the autonomy of scientists, created the Raman Research Institute eschewing government resources and influence. How many people know that he established a small industrial unit in Bangalore, manufacturing and marketing mantles for petromax lamps by installing circular knitting machines for cylindrical cotton product, subsequently soaking the material in cerium salts? The income generated contributed to the functioning of the Institute for 25 years. In Calcutta, scientists such as U P Basu and P C Ray promoted Bengal Chemicals, Calcutta Chemicals and the Bengal Immunity Company to produce fine chemicals, drugs and vaccines. The Haffkine Institute, with distinguished scientists such as Sir Sahib Singh Sokhey, developed biochemical therapeutics and vaccines. The Pasteur Institute at Coonoor, produced vaccines. The Nutrition Research Laboratories, originally in Coonoor, had many scientists, such as Prof V Ramalingaswamy and Dr C Gopalan, who went on to become heads of the Indian Council of Medical Research. In Jammu and Srinagar, the Drug Research Laboratory, under Col Sir Ramnath Chopra, carried out extensive investigations into the chemical constituents of plants and marketed several drugs through a company which continues to function.

In a spirit of nationalism, scientists trained abroad, such as Dr Khwaja Hameed started CIPLA, a major pharmaceutical research and production organisation. The Indian Lac Research Institute promoted production of shellac. Prof T R Seshadri, who worked with Sir Robert Robinson in London on the structure and synthesis of natural products used as pharmaceuticals and dyes, created, on his return, active Schools of Research in Andhra and Delhi Universities, and these have continued to make outstanding contributions. Kasturbhai Lalbhai, an ardent patriot and industrialist in textiles, aware of the problems of import during the Second World War, arranged to train a cousin at the Massachusetts Institute of Technology, USA, and started Anil Starch, producing starch-base and textile auxiliaries. Cellulose Products in Ahmedabad, and Laxmi Starch in South India, represented such offshoots.

India's technological advances owe much to the inspiration and patriotism of her scientists

Industrialists in Bombay such as Tata, Chinoy, Wadia, and Darbari Seth, have all promoted Indian technology and chemical industry. G M Modi in Meerut, Girdhar Lal and Lala Shri Ram in Delhi, diversified into alkali chlorine, and hydrogenated oil industries, as did Seshasayee in South India and G D Birla in Bengal and Western India. Industrialists from Chettinad in South India started educational technology institutions (Annamalai University, Alagappa Chettiar College of Technology) and chemical and fertiliser industries such as Parry and Co, and Southern Petrochemicals. Travancore State with its enlightened policy on education and science also promoted manufacture of fertilisers, rayon, aluminium and titanium. The Princely State of Baroda established a University and promoted modern industries. Some industrialists of Bombay, such as Sir Vithal Chandavarkar, promoted training and research in textiles, chemicals, pharmaceuticals, dyes and vegetable oils through a new University Department of Chemical Technology. Similar initiatives were taken in Kanpur by industrialists such as Singhania of JK Industries, promoting the Hartcourt Butler Institute of Technology, Kanpur University, and the National Sugar Institute and in Nagpur by Jamnalal Bajaj through the Nagpur Institute of Technology.

India was an exporter of vegetable oils until 1956. All those engaged in oil milling and vegetable oils produced electrolytic hydrogen, for hydrogenated edible fats to supplement milk-based ghee. They were also manufacturers of soaps (Tata Oil Mill, Calcutta Chemical, Modi, Sarabhai Swastik Godrej, Lever). Hydrogen was obtained from alkali units and chlorine led to hydrochloride, bleaching powder, chloro-hydrocarbons and PVC with carbide-based acetylene.

Scientific equipment for experimental work was designed and fabricated by scientists with skilled technicians. Raman, J C Bose, and M N Saha made their pioneering discoveries in this way. The construction of a mercury vacuum pump by Venkateswaran led to the Waran pump. Scientific instruments production was ushered by Toshniwal and Andhra Scientific Company from laboratory experience. Skills in glass blowing and lens grinding were imparted to students.

Scientific equipment

There are numerous instances of total technologies before independence in local raw material based chemical processes, and isolated cases of scientific measuring equipment, because of the demands for consumables.The manufacture of capital goods other than building materials, small arms and boats was not widespread. Even in buildings other than bricks, cement and structural steel, items such as ceramics, pipes, valves, sanitary fittings, fans and electrical components, including bulbs, were imported. The exceptions were S L Kirloskar, T V Sundaram, and P S G Naidu, who introduced rotating machinery. Ship building continued in Mazagaon, Surat, and Hubli, although all instruments, engines and equipment were imported.

A significant initiative for the growth and diversification of the chemical industry in Western India arose from the close association of Prof K Venkataraman, then Director of the Bombay University Department of Chemical Technology, and Dr Pai, a member of the Allied group of scientists, during the study of records of the German chemical giant Badische Anilin Soda Fabriken, immediately after the end of the war in Europe. Details of the technological processes for the production of numerous synthetic dyes and pigments for textiles were gathered. Prof Venkataraman continued further research and pioneered the development and manufacture of synthetic dyes. He has recorded these in the 26 monumental volumes on the chemistry of synthetic dyes. The production of synthetic dyes, intermediates and basic raw materials from coal tar by numerous large, medium and small units resulted. Textile auxiliaries, detergents, and emulsifiers, were added to the list with investments by textile manufacturers and their families and employees. Production units were established in outer Bombay and Pune, as well as in many centres such as Vapi, Bulsar, Surat, Ahmedabad, Rajkot and Baroda.

Soon after independence, the need for new technologies and products became apparent. New petroleum refineries with total technology were established in Bombay and Vizagapatnam initially and subsequently in other coastal locations in Madras and Cochin. Apart from the discovery of oil from a surface leak in Digboi, and the later construction of a 0.3 million tonne fractionation unit by the Assam Oil Company, exploration for petroleum in India was not favoured by any foreign companies.

Oil exploration

Then came the discoveries of very large petroleum oil and gas reserves in new locations in the Persian Gulf, Middle East, Siberia, Nigeria, Algeria, Mexico, Brazil, Venezuela and in the offshore North Sea.This changed the picture regarding energy availability, storage, transport and usage. The low price initially prevailing with oversupply allowed a vast expansion of petroleum refining, gas fractionation, gas liquefaction and the replacement of coal as a raw material for chemicals and as a source for rail transport, electrical power generation, and as fuel for heat and cooking. As solid coal use needs ash disposal, and the cleaning of flue gases to meet new stringent environmental standards, petroleum oil and gas based technologies made a significant headway. As oil fluids are of uniform composition, the economies of scale of production in chemicals and energy have radically altered. Batch processes are replaced by continuous processes. The potential role of petroleum, was recognised in India by the then Oil Minister K D Malaviya. Supported by Jawaharlal Nehru, the minister paved the way for establishing the Oil and Natural Gas Commission in 1956 for the exploration, production and processing of oil and for conversion of this resource into to major chemicals, polymers, and fibre products.

Onshore oil and gas discovery in Gujarat in Western India led within seven years to the establishment of an inland refinery in Baroda under the government-owned Indian Oil Corporation, with Russian technology and equipment; it provided Indian engineers with an excellent opportunity to be associated with the transport of heavy large equipment, and its erection, joining, testing, commissioning and operation. The Russian Agency accepted the concept of total technology delivery responsibility while utilising Indian services. This experience in the Indian public sector oil processing industry has blossomed into a major internationally accepted sophisticated capability.

At a time when coal was the major resource for chemicals, the sustained efforts of a group of scientists, technologists and engineers at Sindri, situated in the area of coal mines, outlined processes for the preparation of ammonia fertilizers. They formed part of the large Government-owned Fertilizer Corporation of India as a research, development, and design engineering project organisation.

Catalysts

They were able to develop and produce several high quality catalysts for use in the production of ammonia and products such as urea and ammonium sulphate and phosphate. Several manufacturing plants were also established in different parts of India. This experience of local development was valuable. The availability of petroleum gas, fuel oil and naptha made such basic materials more attractive from 1970 onwards, when in co-operation with a major Italian project organisation, larger single stream energy efficient ammonia plants were designed and constructed. A similar design and project service organisation has been developed by Fertilizers and Chemicals Travancore Ltd. The Council of Scientific and Industrial Research has grown to be the major research and development organisation. Processes developed for batch production of basic aromatic organic chemicals have been absorbed, adapted and improved. The conversion of a laboratory research preparative process needed substantial pilot plants, design engineering and equipment fabrication capabilities. These had to be developed by professional design engineering project organisations, not available in India during the first quarter century after Independence. There were very few units capable of fabrication of reactors, heat exchangers, furnaces, valves, and instruments and these could not easily be imported due to the need to conserve currency in the two decades after 1960.

During this period of about 15 years, there were many instances of medium size organisations evolving their own processes and products, mainly of a non-capital goods nature, towards self-reliance, self-sufficiency and some export. Most of these utilised natural local resources which had not been well developed or even identified. The country became a major producer of essential oils, natural and synthetic terpenic perfumery and flavour materials utilising, among others, pine oils, citronella, palmarosa, citrus, linaloe berry, geranium, lemongrass, and vetiver. The industry has grown several fold with substantial technological advances. Likewise organisations such as the Indian associate of Unilever identified many unusual seed oils and developed technologies for augmenting supplies of oils for industrial use. An outstanding example is also the development and growth of non-soap detergent in a bar form in India representing a world-class innovation. There are successes stories relating to textile auxiliaries, additives, and modifiers, and food colours and dyes. Others relate to leather and leather goods with strong technological development from the Central Leather Research Institute.

Milk revolution

Another breakthrough was in milk and milk products, covering the full range of animal husbandry, collection from small farmers and processing. Dr V Kurien provided a dynamic leadership and worked out the entire operation including the production of stainless steel vessels and other capital equipment. A milk revolution was thus ushered in by the Indian Dairy Corporation and the Kaira Milk Producers Co-operative.

The Government of India recognised the increased demand for petroleum products as fuel for lighting, cooking and transport as well as for efficient fertiliser manufacture. The Ministry of Petroleum and Chemicals supported the move to upgrade Indian capabilities by forming a partnership with Bechtel USA. Thus a company named Engineers India Ltd. was established. The original objective of building five energy efficient high capacity nitrogen fertiliser plants from 1966 onwards did not fructify and Bechtel withdrew from the partnership transferring its shares to the government. Engineers India concentrated on petroleum refining, petrochemicals, polymers and fibres.

Two other major initiatives by the government through the Ministry were directed to maximise technology delivery from highly co-ordinated Indian efforts. The first was the formation of the fully government-owned Indian Petrochemicals Corporation Ltd in June 1969 to produce intermediates for the production of polyester and a major complex including olefins from a naptha cracker and other plants for conversion of olefins to polymers such as linear polyethylene, polypropylene, polybutadine rubber, polyvinyl chloride and olefin based acrylonitrile and its conversion to acrylic fibre. Production of other major chemicals such as linear alkyl benzene (made only in Spain at that time) and ethylene oxide/glycol was also planned. Only very small quantities of nonlinear polyethylene, PVC and polyester had been produced in the country at that time. The second major decision was in each case to purchase processes and for some items basic engineering only. All common systems for 18 different utilities and processing of effluents and byproducts, as well as the overall integration of the entire complex including storage and safety was assigned to IPCL.

Detailed engineering

The entire detailed engineering, requiring over three million man hours, as well as procurement, inspection, certification during fabrication in supplier plants, construction planning and supervision of erection at site services were assigned to EIL, in addition to basic engineering for some projects and in total utilities and infrastructure.From 1972 the National Committee on Science and Technology formulated strategies to meet needs of self-reliant growth in every sector, under the dynamic leadership of the then Minister, Mr C Subramaniam. Excellent detailed reports resulted from close interactions with hundreds of scientists, technologists, engineers and leaders in education, research development and industry. Such national consultations and commitment to a vision of science-based development led to policies for rapid achievements. These are reflected in the commitments in EIL and IPCL. The Department of Science and Technology was established to implement the plans.

A four-member action committee on public enterprises was established, under the chairmanship of M S Pathak who simultaneously held the positions of Member, Planning Commission, and Chairman and Managing Director, EIL. Several public sector enterprises in each sector were merged. Ailing private units in cotton, jute textiles and pharmaceuticals were acquired by government for rehabilitation. An action plan for research and development in such enterprises was prepared. Among those engaged in this rapid transformation, a key role was played by Lovraj Kumar, the first Rhodes Scholar from India, who, after association with the oil industry through Shell in Bombay, joined the Government. He led a group to support EIL and IPCL from the early '60s and functioned as a non- executive member of their Boards. He promoted linkages between public sector companies, universities and research institutions.

The development of IPCL by successfully mobilising a very large number of Indian industrial units to accept challenges for design and fabrication of complex special items of equipment generated high motivation within the company, EIL and others involved. New project teams for each of the 15 projects in both companies accepted near impossible targets and 70-hour working weeks. The group in operations of the plant for xylene and terephthalate achieved record production and profit, restoring overall confidence.

Malaviya's role

K D Malaviya patiently absorbed the details of the developments and potential in petrochemicals and arranged an audio-visual presentation to Prime Minister Indira Gandhi, all senior Ministers and Planning Commission Members in the Prime Minister's Committee Room in August 1975. The room, little altered since 1926, had to be provided with electrical wiring for plug points to enable the use of audio-visual equipment. This resulted in the release of financial resources and government interest in the use of polymer fibres for national development in sectors such as water conservation, agriculture, food storage, health and medicine, energy, transport, housing, education, telecommunications and national security.

Earlier these materials had to be imported and there were severe restrictions on such imports. Several new measures were taken, such as the creation of the Central Institute of Plastics Engineering and Technology at Madras, with Regional Centres. A National Committee on Plastics in Agriculture helped to promote the use of plastics by farmers and in water management, food packaging and transport. Plastic and fibre processing equipment manufacture received attention. Large numbers are employed in small units in acrylic fibre knitting and in fabrics and garments production. Employment generation and economic development from these has been very high with small investments. Similarly a project on polyester filament yarn promoted by IPCL as a new corporation adjacent to the olefin complex added 3500 tonnes of yarn to the meagre 1200 tonnes available in 1978 and made the material available, overcoming shortages and high prices. These initiatives were successful. The polyester yarn and fibre production exceeded one million tonnes per annum in 1998 and prices have been continuously reduced.

The implementation of the IPCL cracker complex projects involved generation of entirely new capabilities in the country in the fabrication of a wide range of items of equipment to international standards. Several public and private sector engineering companies were given orders for supply of equipment not made by them then, on an understanding they would obtain know-how and technology. In other cases, IPCL arranged for expertise from abroad and provided large loans to such companies for acquiring machines needed. Stagewise inspection at the production units and constant requalification of welders as well as raw materials such as steel, SS sheets, special alloy tubes, valves, pumps, motors, and flameproof fittings enabled suppliers and fabricators to meet quality standards.

Cracker

Notable among these units are those of Bharat Heavy Electricals Ltd in Tiruchi and Hyderabad. Bharat Heavy Plates and Vessels Vizag, KGF Bangalore, Bharat Pumps and Compressors Allahabad, Larsen and Toubro, Kaveri Engineering, Kota Instruments and Bestobel. Similarly several new Indian groups were mobilised to carry out major projects of mechanical erection, one for each of the 15 projects and additional groups for 18 shared utilities systems. About 800 persons were trained to qualify as Class I welders by IPCL. Many moved to West Asia to meet very large demands in processing oil and gas and yet about 200 could be available at any time to the mechanical erection contractors. National and private scientific research institutions provided vital inputs. The Department of Aeronautics of the Indian Institute of Science carried out wind tunnel tests to determine destructive resonance vibrations on models of a pair of towers resulting in a change of distance of separation from the original plan. The Associated Cement Company R&D Centre in co-operation with IPCL developed molecular sieves and arranged to supply them. The National Chemical Laboratory, Pune, developed basic process designs for manufacture of four acrylate esters by IPCL for which technology from other sources was not available. The joint efforts of NCL, IPCL and EIL resulted in successful production on a large scale of all these despite the risks of corrosion and explosive heat generation in unexpected polymerisation. The Central Electrochemical Research Institute of the CSIR and the Bhabha Atomic Research Centre contributed in corrosion prevention technologies.

Another breakthrough was the development of new high performance catalysts for hydrocarbon reforming and isomerisation. This was achieved through co-ordinated efforts by the NCL, the Indian Institute of Petroleum of the CSIR and the IPCL. These were then manufactured by IPCL and used in several refineries and in IPCL itself. This laid the base for further development, international co-operation and export of technologies in a highly sophisticated and competitive area. Catalysis has also been the interest of the Fertilizer Corporation of India at Sindri, situated amidst coal mines. It has provided major catalysts in the fertiliser industry. Research studies in IISc Bangalore and later in the Indian Institute of Technology, Kharagpur, were very valuable. India is among the leading countries in homogeneous and heterogeneous catalysis R&D and is providing many technologies in chemical, petroleum, gas, petrochemical, fertiliser, pharmaceutical, and pest control agent industries and for meeting environmental standards in power generation, automobiles, primary metals, metal forming casting, foundry and glass ceramic industries.

Separation process

Another important development is in the involvement of EIL in separation processes. The Heat and Mass Transfer Division designed valve trays for distillation columns and arranged for their fabrication by Godrej Ltd Bombay from 1975 and installation in units in IPCL and refineries for high efficiency separation and purification of fractions of liquids and liquefied gases. Constant improvements are being made to remain competitive internationally. Molecular sieves for separation and drying have been developed by ACC. EIL is also assisting in a project on water desalination by membranes in co-operation with the Central Salt and Marine Chemicals Research Institute, Bhavnagar, and Madras Refineries Ltd. Total technology for large scale liquified petroleum gas production in India was accomplished in 1978 by EIL and resulted in the establishment of plants in Uran near Bombay by ONGC and their operation by IPCL personnel. Addition of many such units from Bombay High Gas has led to very high increase in local production of LPG and in the entire equipment supplied from Indian sources. Recognition of these capabilities got EIL assignments in Algeria and Abu Dhabi as the managers for LPG and liquefied natural gas projects then being executed by US and Japanese companies. An unusual case of technological knowledge and delivery experience was the iron ore water slurry pipeline in Karnataka, transporting ore to Mangalore port for export to Iran in 1977-80. An R&D and pilot project initiated by EIL in the Regional Research Laboratory Bhubaneswar in Orissa gave some basic insights which could be applied to the Karnataka Project with specifications evolved by Canadian Metchem. These were revived by EIL and the plant has been operated successfully. There are numerous opportunities for such transport of coal, ores and byproducts in non-ferrous metal units. In winter, slurry problems in waxy crude in the Bombay High transport pipelines to Mathura Refinery near Delhi often need remedial measures.

Blood bags

A remarkable institution developed by Prof M S Valiathan, the distinguished medical research scientist and heart surgeon, is the Chitra Tirunal Centre for Medical Science and Technology at Thiruvananthapuram in Kerala on the south west coast of India. The technology wing is renowned for its development of a PVC special polymer bag for human blood collection, storage and transport.

Technology was delivered to a new company for manufacture of one million bags in 1986 at a time when such technology and production was limited to Japan and Korea. The technology has revolutionised blood availability for critical use and has allowed increased production to five million bags per annum. Technology is being transferred to other developing countries.

Equally brilliant has been the evolution of design, fabrication and testing to meet the highest international standards, of the Chitra Heart Valve, and its manufacture in India.

CIBA recognised the potential for new drugs from natural material after the extraordinary success of its Reserpin The company started a major modern research centre in Bombay 1961. It was inaugurated by Pandit Jawaharlal Nehru in the presence of several Nobel Laureates, including Robert Robinson, Vladimir Prelog, Robert Woodword and Alexander Todd. Under the direction of Prof T R Govindachari, who had worked with Roger Adams, a brilliant team of organic chemists and biologists at the centre trained a large number of researchers. The centre did not continue but its scientists have worked in many research institutions related to industry in fine chemicals. India has built up significant capabilities in the sectors of synthetic drugs, agrochemicals, speciality chemicals, synthetic dyes, and textile auxiliaries. The Indian Institute of Chemical Technology, Hyderabad, the NCL, and the Central Drug Research Institute, Lucknow, have demonstrated expertise for total technology development and transfer also in hydrogen cyanide and cyanuryl chloride.

State support

Technological capability is achieved through state support and by creating an appropriate investment climate for commercial companies. The contracts given by the government to aircraft and defence systems companies for new developments allowed a large write-off. In many countries, companies are free in any year to decide on the percentage of claim for depreciation of capital assets and deduction from profits. These encourage high-risk high-profit ventures in frontier areas. Governments have prmoted mergers of related businesses to evolve strong national companies, as in in aircraft, automobiles, chemicals, telecom and computers in Europe and America.

And as for the Intellectual Property Rights, their non-operation in Eastern Europe and in specific sectors in some countries in Western Europe, the Far East and Central/South America for one to four decades before 1980 contributed to self-reliance. The Hippocratic Oath taken by practitioners of medicine and surgery enjoins them to apply knowledge and skills and propagate and transfer them openly. Such standards are now regarded by many as inhibitory to innovations and to the progress of mankind ■