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Chemical Engineering Education and Practice in Bangladesh

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Abstract

Chemical Engineering as a distinct engineering discipline is now more than hundred years old. It was 1888 when Professor Louis Mills Norton first introduced the curricula for Chemical Engineering at MIT. As creative chemists came up with new chemicals it provided ever new challenges to the Chemical Engineers to innovate new industrial processes applying the new found knowledge in unit operations, unit processes, reaction engineering, process control, (later) transport phenomena and (recently) process integration.

In Bangladesh the founding fathers of engineering education took a long term view of the industrial development prospects and took the innovative decision to introduce Chemical Engineering curricula in the erstwhile Ahsanullah Engineering College in the early fifties. During these early years large corporations in the public sector provided the initial thrust for development of chemical and process industries. However it was not adequately appreciated during the formative years that mere experience in the successful operation of complex chemical plants does not constitute technology transfer in the real sense of the term.

Professional in the field stressed the need for setting up of design sections where local chemical engineers with inputs form relevant professionals would be able to contribute meaningfully in establishing the design criteria for a plant. In the private sector Chemical Engineers have demonstrated in Bangladesh that they can be innovative in transferring technology and developing Ceramic and medium scale Basic Chemical industries. Thus, it has been amply demonstrated that accumulating technological capacity through such dynamic technology transfer efforts should be one of the avowed objectives of any development process. Professional Capability and Areas of Competence of Chemical Engineers have grown over the years in this country and this issue has been elaborated with specific examples.

1. Introduction and Background

Chemical Engineering as a distinct engineering discipline is now more than hundred years old. The first century of growth of Chemical Engineering has been synonymous with the phenomenal growth in industrialization throughout the world. Demand for new products, increased efficiency, better resource utilization, high purity outputs and, more recently, the emerging world of bio-technology have provided this discipline new challenges which have been met adequately.

The traditional batch processes employed before the onset of the industrial revolution mostly involved manufacture of common acids, alkalis and some salts. These processes, obviously, involved straightforward chemical reactions taking place at normal atmospheric pressures. The technical manpower for these industries did not really need extensive university education. However, credit goes to the innovative industrial chemists who were the standard bearers of these industrial units during those days. The number and variety of products being limited, it was possible for an industrial chemist to specialize in a particular industry and spend a whole lifetime, first trying out "learning-by-doing" and later attempting to improve the particular process. Knowledge of chemistry and relevant experience in a particular industry were sufficient to run those industries.

2. Birth of a new Engineering Discipline

Perhaps the seeds for a new discipline were sown during late 19th century with the development of process for the manufacture of synthetic dye and continuous processes like Solvay soda ash process. The contact

process for sulfuric acid evolved during 1870's.
Early 20th century saw the growth of petroleum refining industries that, to start with, involved several physical separation processes. This was followed by several downstream industries incorporating chemical reactions like cracking, hydrogenation, chlorination, nitration, etc. With the rapid diversification of chemical and process industries it became obvious to both industry and the academic world that it was no longer possible to serve the sector purposefully with the help of industrial chemists specialized only in single industries.

On both sides of the Atlantic designs for the first curricula of the new discipline of Chemical Engineering emerged. It was 1888 when Professor Louis Mills Norton first introduced the curricula for Chemical Engineering at MIT. About the same time the "Manchester Technical School" (Now UMIST) had offered 12 lectures that contained elements of the new discipline. In 1904 G.E. Davis published the first "Handbook of Chemical Engineering" in Manchester. Arthur D. Little in 1915 proposed to MIT the concept of "unit operations", the idea that an operation such as distillation, gas absorption, filtration etc. could be applied to a number of different materials of different characteristics in different chemical and process industries. Consequently, it was no longer essential to specialize in operation of individual manufacturing processes as the industrial chemists were used to. Chemical Engineers began to be treated to a unique curricula which provided tools to adapt themselves quickly to the ever changing world of chemical and process industry. As creative chemists came up with new chemicals it provided ever new challenges to the Chemical Engineers to innovate new industrial processes applying the new found knowledge in unit operations, unit processes, reaction engineering, process control, (later) transport phenomena and (recently) process integration.

It is interesting to note that Chemical Engineering as a distinct profession remained rather vaguely defined in continental Europe till the Second World War. Germany, for instance, stuck to the 19th century concept of developing and operating chemical industry with "cooperation" between industrial chemists and mechanical engineers. The "Chemical Engineering Approach" was perhaps considered as a typically Anglo-American concept. However, a sea change occurred after the Second World War and both industry and the tertiary education system realized the need for rapidly adopting to the "Chemical Engineering way" in order to complete globally. Thus, the first "European Symposium on Chemical Reaction Engineering" was held in 1957 and the German universities - Dortmund, Karlsruhe, Erlangen and others started developing independent departments of Chemical Engineering during 1960-70 according to the American concept.

3. Beginnings in Bangladesh

The founding fathers of engineering education in the then East Pakistan took a forward looking decision in establishing the "Department of Chemical Engineering" in 1948 in the erstwhile Ahsanullah Engineering College. This was done in the fond hope that graduates form the department would play a pivotal role in industrializing the newly independent country. This was indeed a hold step considering the fact that the profession was yet to have wide acceptance outside the Anglo-American sphere of influence. As mentioned in the earlier section, even in Europe independent departments of Chemical Engineering were not yet popular. In this respect the academic initiative and intellectual courage demonstrated by Prof. M.A. Naser, Late Prof. A.Q. Chowdhury, Prof. Syed M. Mazharul Huque and others are indeed praiseworthy. However, while the academics were ready to produce graduates in this new and promising profession, industry was yet to appreciate the role of a Chemical Engineer. The first batch of

Chemical Engineers graduated in 1952 and during the initial years only a few graduates were produced. Demand for such graduates from industry was virtually absent and industrial leaders with proper appreciation of the unique features of a Chemical Engineer's training were hard to come by.

During the late fifties of the 20th century an important development in the field of engineering education in the country took place with a strong and meaningful academic linkage program between the Ahsanullah Engineering College (AEC) and US colleges of engineering. Under this program Dr. Olaf Bergelin, a renowned faculty from a highly ranked department of Chemical Engineering of the University of Delaware was assigned to help the department grow in stature. Dr. Bergelin came with a missionary spirit and helped develop an academic program comparable to current international standards and interacted with industry to explain the role of the profession as evidenced in industrialized countries. It was a time when natural gas-based industries (e.g. Urea) and paper industries were either being planned or implemented in the country. The ChE faculty at AEC took pains to impress upon the then industrial leaders the need to utilize the members of the new profession. However, the senior technical leaders of industry (largely in public sector), with training and experience in the older mode of running chemical and process plants with chemists and mechanical engineers, were hesitant or reluctant to take the "risk" of employing engineers about whose training and purpose they were only vaguely familiar. This author, after graduating from the department in 1960 applied for the position of an Assistant Chemical Engineer in a sugar mill. He was asked to appear at an interview for the post of an Assistant Chemist. When he tried to explain the role of a Chemical Engineer to the interview board he was finally offered the position of an Assistant Mechanical Engineer! This personal anecdote typically demonstrates the "confusion" that reigned during the early days of this profession in this country.

4. Chemical and Process Industries in Bangladesh

In the industrialization of Bangladesh, the first choices with respect to technology were comparatively easy. Industries that could help the growth of agriculture, agro-based industries, e.g. jute and traditional production units for import substitution such as textile and sugar, got preference for obvious reasons. Their technologies were not complicated. For instance, textile, jute, and sugar technologies are relatively simple and repetitive and one only needs more machines, more capital formation. These are also largely final-consumer-goods industries. But succeeding choices have been difficult and required considerable background studies and search, and properly qualified technological manpower.

At the time of partition, there were only five sugar mills and one cement plant. In the early fifties, the then Pakistan Industrial Development Corporation set up the paper mill at Chandraghona based on bamboo and it went into commercial production in 1953. With this paper mill came a number of chemical plants on the same site including sulfuric acid, lime, alum, sodium hydroxide, chlorine etc. Some of the milestones of the development of major chemical process industries in Bangladesh are listed below.

MILESTONES OF DEVELOPMENT OF CHEMICAL PROCESS INDUSTRIES IN BANGLADESH (source: Quader)

Sugar	1933
Distilleries (fermentation of molasses)	1938
Portland Cement	1941
Paper and Pulp	1953
Sulfuric Acid	1953
Sodium Hydroxide & Chlorine (chlor-alkali)	1953
Alum	1953
Bleaching Powder	1953
Lime	1953
Urea and Ammonia	1961
Rayon	1967
Carbon disulfide	1967
Petroleum Refinery	1968
Ammonium Sulfate	1969
Natural Gas Processing Plant	1969
Triple Super Phosphate	1972
Insulator and Sanitary Wares	1980
Visbreaking	1995
Industrial Gases such as CO_2, O_2, C_2H_2 etc.	Exact date not known
Ceramic and Refractories	Exact date not known
Glass	Exact date not known
Pharmaceuticals	Exact date not known
Food products	Exact date not known
Fine chemicals	Exact date not known

Large corporations in the public sector provided the initial thrust for development of chemical and process industries. The private sector was involved only in small/medium industries like Soap, Detergents, Cosmetics, and Pharmaceuticals etc. However, since the decade of the eighties there has been a gradual shift in emphasis and the sate owned enterprises are being disinvested and the private sector is being encouraged to participate in almost all sectors/sub sectors of industry. Indeed, recent trends show that within the chemical/process sub sector, the

private sector has shown considerable interest in setting up several industries viz., Cement, Ceramics, Pulp and Paper, Pharmaceuticals, Agro and Food Processing, etc. However, KAFCO remains the sole instance of private sector involvement in a large chemical process industry.

The contribution of the manufacturing sector to GDP has crossed the double figures recently. In terms of their share in manufacturing GDP, the Chemical and Pharmaceutical sub sector contributes nearly 20%. This does not include the contribution of natural gas based industries like fertilizer or imported crude based refinery. In view of the government control of output prices the value added figures for petroleum and fertilizer industries are very low according to Bangladesh Bureau of Statistics. It is felt that their true contribution to manufacturing GDP is not fully represented in such economic measures. One needs to measure the **"technology content added"** along with "value added" in order to truly measure the contribution of complex units like modern chemical process industries. Given these distortions, the contribution of chemical process industries is perhaps not truly reflected in statistics.

5. Early constraints in the Development of the Profession

The first urea fertilizer factory in the country went on stream during 1961-62. Since then six more urea plants and one TSP plant have been installed. All of them were developed under foreign assistance. Except for one plant that was constructed under a cost plus fee basis, all the plants have been done under turnkey contracts.

After Bangladesh became independent, she already had two urea fertilizer factories and was planning for the third. Which meant technical personnel with more than ten years plant experience were available in the country? However, at that point of time these were only a few Chemical Engineers employed in the plants and none were in leadership positions. The donors while assessing the in house technological capability remained unimpressed and suggested that for the planned Ashuganj urea plant a large number of expatriates should be put in place at each and every stage of planning, implementation and operation. The World Bank in its appraisal reports commented, "There are major risks involved in the projects. To build a complex fertilizer plant in a country of Bangladesh's state is in itself a formidable undertaking".... "No country, but least of Bangladesh's general state of poverty and limited resources, can afford inefficient project implementation and the introduction of expatriate expertise in project management as well as production functions in addition to the Engineering Firm and the Technical Adviser and their clearly delineated responsibilities as well as their smooth cooperation with the Bangladesh staff is a sine qua non for a successful project."

Due to lack of vision of the industry leaders, the donors took the upper hand. Thus, we cannot avoid the blame of not having taken any initiative in institutionalizing local technological capability in respect of technology assessment and design engineering. The first fertilizer factory in the geographical area that now constitutes Bangladesh went on stream as far back as 1961. Yet no initiative had been taken in the meantime to develop engineering design and development capacity in this particular field. It is painful that we have not done it yet! Mere experience in the successful operation of complex chemical plants does not constitute technology transfer in the real sense of the term. Granting that it takes longer gestation period to develop the hardware part of such technologies in a developing country, it should have been possible by then to have 'in house' capability in the various software aspects, viz., identification of various components of the technological packages to be imported, checking of the process design information, tender evaluation of vendors' offers and installation of the various components of the plant. Had it been possible for Bangladesh to develop such capabilities at the time of the World Bank appraisal of the Ashuganj Project, it would not have been necessary to introduce the extraordinary step of accepting expatriates at every stage of the project.

Lack of initiative from industry leaders and decision makers, invisible wall of resistance from vested quarters and professional rivals often created road blocks in the development of the profession during the early years. However, during the rehabilitation work of the Natural Gas Fertilizer Factory (NGFF) local expertise was "trusted" and some members of the profession along with other professionals got an opportunity to make significant contribution and thereby gained first hand experience in a major "turn around" work without expatriate assistance. A significant step forward in the development of the profession was achieved during the planning of the Chittagong Urea Fertilizer Factory. A design section was set up for the project and local chemical engineers with inputs form relevant professionals were able to contribute meaningfully in establishing the design criteria for the plant. Substantial cost reduction in certain sections was possible through changes incorporated in the original design of the plant. In implementing the Jamuna Fertilizer plant members of the profession were also able to play a major role during the project management stage that included participation (often without expatriate assistance) in procurement, inspection, scheduling, construction, installation and commissioning of the plant. During the design stage of CUFL an offer was made form UNDP/UNIDO for assistance in setting up of a full-fledged Engineering Design Division in BCIC. However, the project got lost in the bureaucratic maze in the Ministry. Here was an opportunity for Chemical Engineers to professionally contribute in an area for which they are specially trained. Sadly, yet another opportunity was lost. KAFCO, which is the only large chemical process plant in the private sector, has been able to reach production targets 15-20% above the nameplate capacity in recent months due to introduction of process changes that were initiated, planned and implemented by local engineers. Being in the private sector, the Chemical Engineers in the plant (along with other relevant professionals) are now able to initiate investment decisions that are not subject to scrutiny by layers of bureaucracy as in case of such units in the public sector.

In the private sector Chemical Engineers have demonstrated that they can be innovative in developing Ceramic and medium scale Basic Chemical industries. Obviously the flexibility and entrepreneurial ambience in those sectors helped them to put into practice their ideas and innate capabilities.

6. Capacity Building

Accumulating technological capacity through technology transfer efforts is one of the avowed objectives of any development process. However, during the early years of industrialization in the country it was often not appreciated that mere transfer of hardware and services for installation and start up of an enterprise does not constitute any transfer of technology at all. In Bangladesh, especially during the early years of industrialization efforts, installation of a manufacturing unit has often been equated with technology transfer. This is obviously wrong. Transfer of mere hardware does not constitute technology transfer.

More often, however, owners have insisted on transfer of skills for the operation, maintenance and trouble shooting of the physical plant. Operating skills involve knowledge of installed process, machinery, instrumentation and protection devices. Besides, one would have to have knowledge and experience about maintenance management, detailed technical stills and some very limited capacity to fabricate simple parts and accessories. However, such transfer still constitutes a "**STATIC**" form of transfer of technology and does not contribute to the long-term goal of technologisation of the sector. During this **"STATIC"** mode of transfer of technology a person trained in Chemical Engineering can only make limited use of all that he or she has learnt.

The ideal would be **"DYNAMIC"** transfer where one obtains the knowledge, skills and experience to manipulate and change the production system and gains the capacity to innovate. Such a transfer constitutes the real addition to a nation's technological capacity.

In spite of the constraints and unnecessary roadblocks in the way of their natural professional development, Chemical Engineers have made their presence felt in several areas of technology absorption and adaptation processes in the country. In the following table the author has attempted to present his personal estimate of the degree of professional capability gained by Chemical Engineers till to date.

Table 1. Professional Capability and Areas of Competence of Chemical Engineers

Activity	Current Level of Competence of Chemical Engineers	Other Professionals Involved
A) GENERAL CONSULTANCY		
a) Feed Stock & Process Evaluation	High	Industrial Chemists and Engineers
b) Bid Document Preparation	High	Other Engineering Disciplines
c) Bid Evaluation	High	Other Engineering Disciplines
B) PROJECT PLANNING		
a) Project Profile	High	Economists, Other Engineering Disciplines
b) Market Research	High	Economists, Other Engineering Disciplines
c) Techno-Economic Feasibility Report	High	Economists, Other Engineering Disciplines
d) Detailed Project Report	Moderate	Economists, Other Engineering Disciplines
C) COMPLETE ENGINEERING		
a) Mechanical	Low	Mechanical Engineers
b) Electrical	Not Applicable	Electrical Engineers
c) Instrumentation	Moderate	Electrical and Mechanical Engineers
d) Civil, Structural etc.	Not applicable	Civil Engineers
D) PROJECT MANAGEMENT		
a) Procurement	High	Mechanical and Electrical Engineers
b) Fabrication	Not Applicable	Mechanical and Electrical Engineers
c) Inspection	High	Mechanical and Electrical Engineers
d) Monitoring & Scheduling	High	Mechanical and Electrical Engineers
e) Construction & Installation	High	Mechanical, Electrical and Civil Engineers
f) Commissioning	High	Mechanical, Electrical, and Civil Engineers
E) ENVIRONMENTAL CONTROL		
a) Air Pollution Control	Moderate	Environmental Scientists
b) Effluent Treatment	Moderate	Civil Engineers, Environmental Scientists

7. Concluding Remarks and Looking Ahead

It has been observed during the past five decades of industrial development efforts in the country that while the issues of "industrialization" is invariably discussed, the question of "technologisation" is often forgotten. Similarly, there is no dearth of arguments put forward to promote the cause of capital accumulation. Yet, the issue of technology accumulation is not pursued with vigour.

It is now well understood in most developing countries that while industrial units can be set up through foreign aid in its various forms, technology is a commodity which has a price tag attached to it. There is no "fixed price" for technology. The price depends on the bargaining capacity of the recipient country. The bargaining capacity is derived from the capability for judicious selection, knowledge of world technology shelf, in-house engineering capability and adequate academic background of the recipient. The profession of Chemical Engineering is poised to play a key role in augmenting this bargaining capacity.

Both for public and private sector projects import of technology in majority of cases have taken place in this country in a packaged form under turnkey contracts. In the public sector most of the projects are funded through external assistance agencies. Technological resources presently being imported are usually processed through a negotiating mechanism, which do not posses adequate technology assessment and assimilation capabilities. The corporations in the public sector do have Chemical Engineers with long experience in relevant enterprises. Lately, these experts have been involved in evaluation of technology proposals. However, institutional arrangements to assess, adapt and absorb the largely imported technology are still in a rudimentary stage. Thus, the sector in general and chemical industry in particular has not yet been infused with an innate dynamism which can propel it to reach new heights of chemical engineering innovation and creativity.

Experience of more successful Asian countries like India, South Korea and notably Japan prove that the weakness of the existing material base does not constitute insurmountable barriers to development of chemical industries provided the human resource base and the socio-economic and cultural environment are deliberately transformed to fruitfully utilize imported technology. Apparently, whatever may have been the role of foreign assistance in those countries; an enlightened leadership received it with an eye towards the ultimate goal of increasing the technological capability of the human resource base.

Successful absorption of imported technology in the country requires institutional arrangements where Chemical Engineers can meaningfully utilize their training and skills. The development activities would include efforts to replicate existing vintages of technology utilizing knowledge accumulated from long years of operating existing plants, design engineering initiatives for adapting some of the processes to suit local raw materials and conditions and pilot plant studies on some promising locally developed processes.

In addition to the current responsibilities for operating and maintaining existing plants, there should be wider scope for Chemical Engineers to provide technical services which will put demand on their innate innovative capabilities leading to increased efficiency, lesser pollution and better product quality in the coming decades.